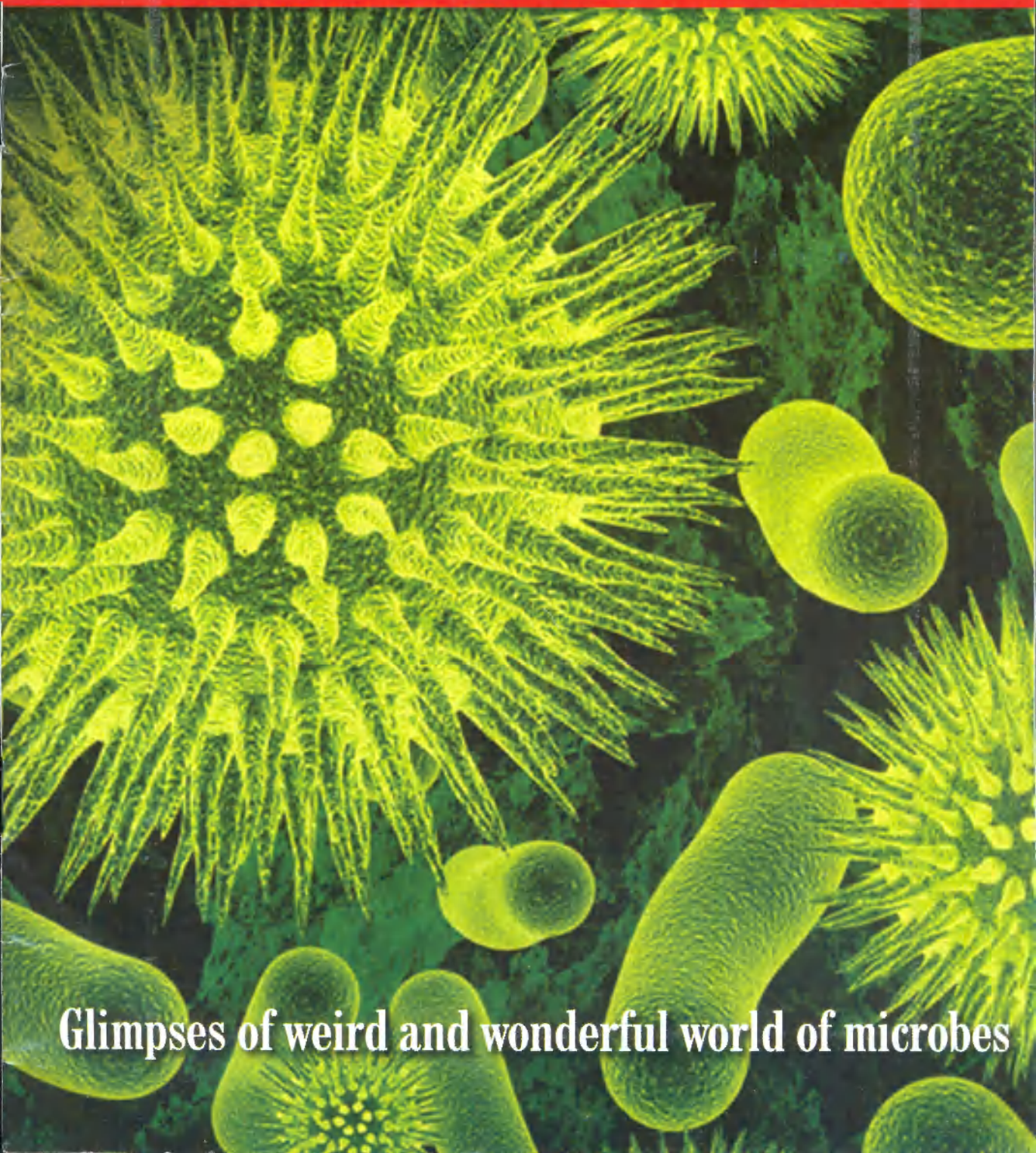
Vol 14. No. 5 May 2011

ISSN 0972 - 8287

SCIENCE INDIA

THE NATIONAL SCIENCE MAGAZINE

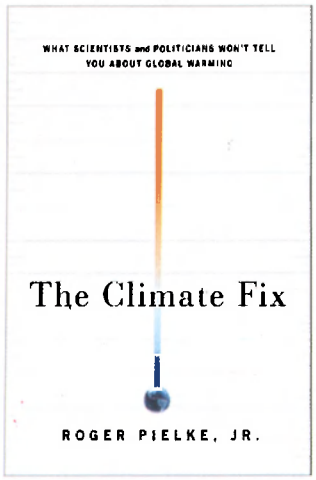
Published by
Swadeshi Science Movement



Glimpses of weird and wonderful world of microbes

BOOK OF THE MONTH

The Climate Fix: What Scientists and Politicians Won't Tell You About Global Warming



Title	:	The Climate Fix: What Scientists and Politicians Won't Tell You About Global Warming
Author	:	Roger Pielke
Publisher	:	Basic Books
Pages	:	288
Price	:	$26
ISBN	:	9780465020522

Why has the world been unable to address global warming? The world's response to climate change is deeply flawed. This book is where we begin to get it back on track. Science policy expert Roger Pielke says it's not the fault of those who reject the Kyoto Protocol, but those who support it, and the magical thinking that the agreement represents. In his latest book, The Climate Fix: What Scientists and Politicians Won't Tell You About Global Warming, Pielke offers a "commonsense approach" to climate policy.

The relationship between humans and the earth system that we inhabit is two-way - humans affect the planet and the earth system processes affect us. This symbiosis is characterised by empirical complexities and uncertainties, the most intense of which is the global climate change debate in recent years. These debates are often characterised by a considerable amount of heat, but unfortunately too little light. Roger Pielke, recommends we should first comprehend why the current approach is failing and then consider better alternatives.

We are invited to read a widely publicized article in the Journal of Climate titled "Why Hasn't Earth Warmed as Much as Expected?" written by top-notch atmospheric scientists (http://wattsupwiththat.com/2010/01/19/brookhaven-national-laboratory-why-hasnt-earth-warmed-as-much-as-expected/). The article is premised on the conclusion that the Earth hasn't warmed as much as expected, and asks why. One possible answer to the "Global-warming time-bomb" is that the prognostic models are too large, a second possible answer is that anthropogenic haze could be offsetting the enhanced greenhouse effect.

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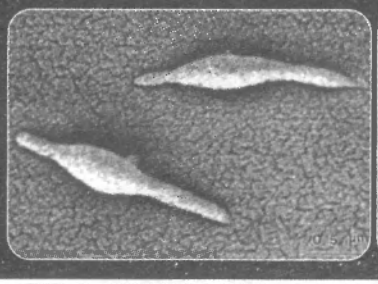
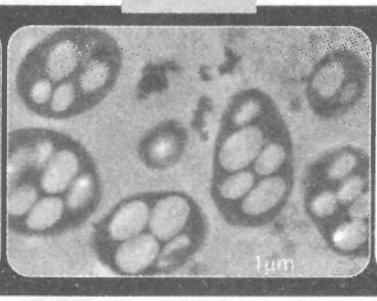
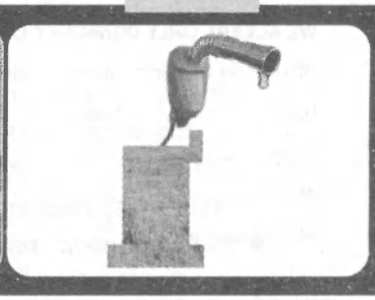
CONTENTS







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Printed and Published by: A. Jayakumar
and owned by Swadeshi Science Movement (Kerala)
B4, Mather Square,Town Railway Station Road
Kochi - 682 018, Kerala, India
Published from Ernakulam

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Printed at: Niseema Printers, Cochin

Editorial

Bacteria - the single-celled microorganisms which can exist either as independent (free-living) organisms or as parasites (dependent upon another organism for life). Examples of bacteria include: Acidophilus *Clostridium welchii,* the most common cause of the dreaded gas gangrene, *E. coli,* the common peaceful citizen of our colon and, upon occasion, a dangerous agent of diseases, and *Streptococcus,* the bacterium that causes the important infection of the throat-strep throat.

The term bacteria was devised in the 19th century by the German botanist Ferdinand Cohn (1828-98) who based it on the Greekword bakterion meaning a small rod or staff. In 1853, Cohn categorised bacteria as one of three types of microorganisms - bacteria (short rods), bacilli (longer rods), and spirilla (spiral forms). The term bacteria was preceded in the 17th century by the microscopic animalcules described by Antony van Leeuwenhoek (1632-1723).

Perhaps the most important discoveries of the recent times is the discovery of 'arsenic eating bacteria' which opened up new possibilities for alien life. A brief article on the epoch discovery of the bacterium called 'GFAJ-1' by Wolfe-Simon and associates from the shores of Mono Lake, California appears in this issue.

Another article on 'Glimpses of weird and wonderful world of microbes' by Dr. Neeta Bhagat and Dr. Nupur Goyal from Amity Institute of Biotechnology, Noida also appears in this issue of Science India.

Team Science India

Glimpses of weird and wonderful world of microbes

Dr. Neeta Bhagat and Dr. Nupur Goyal

" We live on the planet of the microbes, but it's largely unexplored."
"We're entirely dependent on this microbial population for our well-being."

Mi-cro-or-gan-ism (mi'kro-or'geniz'm), is a living creature too small to be seen without a microscope. Some (protozoa) are animals; some are simple forms of plant life (algae, yeasts, molds, etc.); some (bacteria) hold an intermediate place between the animal and plant kingdoms; and some (viruses) are too primitive to be classified as plant or animal. Countless trillions of microbes inhabit every cranny of the globe. They reshape their environment, make life possible and sometimes destroy. Despite their minuscule size, these creatures also have had an enormous effect on land, water and air. Micro-organisms manufacture oxygen, convert nitrogen into forms that plants can eat and drive the cycles of carbon, sulfur, iron and other elements essential to life. Microbes are responsible for generating at least half the oxygen we breathe. Microbes plays a key role in the transformation of Earth to a habitable planet. Microbes out-number all other species and make up about ~60% of the earth's biomass. Less than 0.5% of the estimated 2 to 3 billion microbial species have been identified.

Microbes are roots of life's family tree. An understanding of their genomes will help us understand how more complex genomes developed. Microbial genomes are modest in size and relatively easy to study (usually no more than 10 million DNA bases, compared with some 3 billion in the human and mouse genomes). Microbial communities are excellent models for understanding biological interactions and evolution.

Microbes come in a number of shapes and sizes, but most of these shapes are rather uncomplicated. The easiest shape for a microbe is a sphere, like a soap bubble. The cell membranes of microbes tend to naturally form this simple structure due to forces such as surface tension.

Some rare microbes form radically unique shapes. Using high-powered microscopes, the scientists captured images that show star-shaped cells with four to nine points. It's a unique structure for a microbe and one that has not been witnessed before (Fig 1). The cell membrane of the bacterium twists and

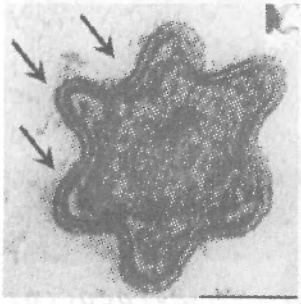

Fig 1.Star Shaped cells
(Courtesy: Wanger *et al.*)

turns to provide its unique shape. The colossus among bacteria is a single-celled giant that lives in the ocean and is named *Thiomargarita namibiensis*, which means "sulfur pearl of Namibia"(Fig 2). It was found in the ocean floor of the coast of Namibia in Africa. *T. namibiensis*'s ball-shaped cells can grow to almost 1 millimeter or 1/25th of an inch in diameter. *T. namibiensis* "eats" sulfur and "breathes" nitrate. It stores these molecules in bubble-like compartments in its cell called vacuoles. These vacuoles take up 97 percent of the space inside the cell and give the bacterium a pearly, blue-green color.

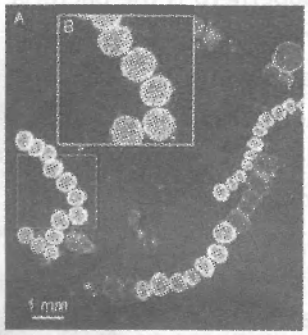

Fig 2. *Thiomargarita namibiensis*
(Courtesy: H.N. Schulz)

The largest bacterium is *Epulopiscium fischelsoni* (Fig. 3) that have been discovered in the guts of a fish found in the warm waters of the Red Sea. It measures 200-700 micrometers. Viewed through powerful electron microscopes, it looks like fuzzy tangles of threads. It is polymorphic and lacks cell wall components.

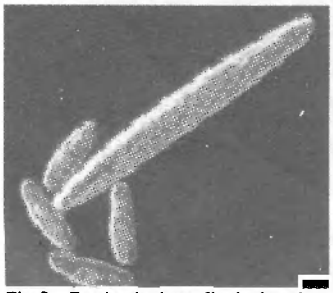

Fig 3. *Epulopiscium fischelsoni*
(Courtesy: Bresler *et al.*)

Did you ever wonder what the world's largest organism is? Maybe you'd pick an elephant or a giant whale. Well, those choices would be wrong; this organism is actually a soil Fungus, *Armellaria bulbosa* (Fig. 4) found in a northern Michigan hardwood forest. It is most likely one of the world's oldest organisms as well, exceeding 1,500 years and weighing over 100 tons. It is actually a plant pathogen, whose hyphae pierce the roots of aspen trees and absorbs nutrients from them. They are also refered to as 'honey mushrooms'.

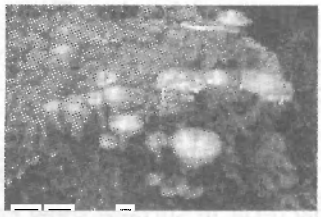

Fig 4. *Armellaria bulbosa*
(Courtesy: Internet)

The smallest of the small are the viruses. The smallest of all are members of a group called the Parvo-viruses. Some of these spherical viruses can be as little as 18 nanometers in diameter

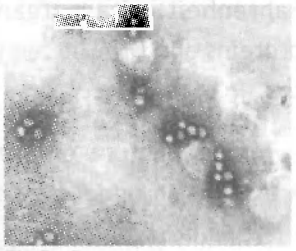

Fig 5. Parvovirus
(Courtesy: Wadsworth Center, New York State Department of Health)

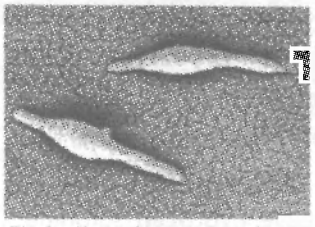

Fig 6. *Mycoplasma pneuniae*
(Courtesy: Duncan Krause)

(Fig. 5). *Mycoplasmas* are the smallest "known" free-living microorganism about 300nm in diameter (Fig. 6).

Microorganisms are 'omnipresent'. They are found in air, water, soil, animals, plants, rocks or even polar region. Microbes thrive in an amazing diversity of habitats in extremes of heat, cold, radiation, pressure, salinity, acidity, and darkness, and often where no other life forms could exist. They also survive different extreme environmental conditions. Certain bacteria grow very well in the cold. Researchers have reported findings of large populations of bacteria in surface snow collected from South Pole. They found 200 to 5,000 bacterial cells per milliliter (there are 5 milliliters in a teaspoon) in the surface snow. These organisms are so tough that they are able to make protein and DNA at temperatures as low as 17 degrees below zero Celsius or about 2 degrees Fahrenheit. If an organism can make proteins and DNA, it can grow and divide too.

Archeabactera or primitive bacteria are found in undersea hot vents, where there is no sunlight and the pressure is around 200 atm, in addition to the extremely high temperature. Some bacteria that thrive well in boiling water temperature (100°C) are called "hyperthermophiles". It freezes to death at temperatures below 70°C. Another exciting feature of these bacteria is that they do not use oxygen; instead they use sulphur and release hydrogen sulphide. Over 3 billion years ago, ancient Earth was probably steaming hot with little oxygen and plenty of sulfur, a comfortable place for *Pyrococcus furiosus* (Fig. 7) to swim and enjoy life. But perhaps one of the most unusual microbial superhero is the bacteria that are highly resistant to absolutely lethal radiation levels. *Deinococcus radiodurans* (Fig. 8) is very remarkable for its ability to withstand radiation levels over 1000 times higher than that which would completely debilitate any human on earth. It is one of the most radio resistant bacteria which can survive cold, dehydration, vacuum, and acid and is therefore known as a polyextremophile. This has been listed as the world's toughest bacterium. Its resistance characteristics are being exploited in the development of bioremediation processes for cleanup of highly radioactive waste sites, and in the development of radio protectors.

Fig 7. *Pyrococcus furiosus* (Courtsey: Henry Aldrich)

Fig 8. *Deinococcus radiodurans* (Courtesy: Michael Daly)

Yet another archeaon which grows in environment of extremely high salinity is *Halobacterium* (Fig. 9). *Halobacteria* can

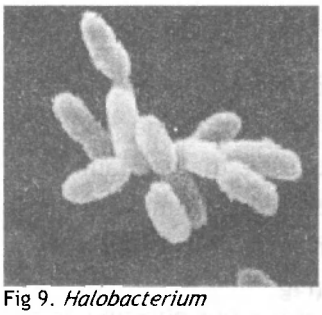
Fig 9. *Halobacterium*
(Courtesy: Internet)

be found in highly saline lakes such as the Great Salt Lake, the Dead Sea, and Lake Magadi. On an interesting note, however, *Halobacteria* are a candidate for a life form present on Mars. One of the problems associated with the survival on Mars is the destructive ultraviolet light. *Halobacteria* have an advantage here. These microorganisms develop a thin crust of salt that can moderate some of the ultraviolet light. Sodium chloride is the most common salt and chloride salts are opaque to short-wave ultraviolet. Their photosynthetic pigment, bacteriorhodopsin is actually opaque to the longer wavelength ultraviolet (its red color) so it can survive in ultra violet radiations.

There are some interesting archeabacteria called *Sulfolobus solfataricus* (Fig. 10) which can survive without sunlight or organic carbon as food is. It works in some of nature's hardest volcanic conditions. It lives on sulfur, hydrogen and other materials which normal organism can't metabolize. It has ADH (Alcohol dehydrogenase) which can survive up to 88°C and responsible for the conversion of alcohols. When bimolecules extracted from these volcanic microbes are stored at room temperature they undergo deep freeze condition compared to their normal lives. This increases their shelf life and stability for commercial use.


Fig 10. *Sulfolobus*
(Courtesy: Brock, Brock, Belly and Weiss)

There is another interesting bacterium that contains fixed magnets that force the bacteria into alignment - even dead cells align, just like a compass needle. When placed near a magnet, they are attracted to the magnet's northern pole because the bacteria make magnetic particles which contain iron. It is this built-in compass that enables the bacteria to find its way down to the deep, oxygen -free parts of its aquatic habitat. These bacteria are called magnetotactic bacteria (Fig. 11).

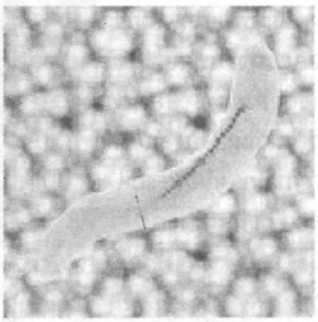
Fig 11. Magnetotatic bacteria
(Courtesy: R. Frankel)

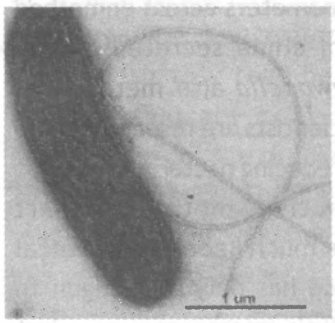

Fig 12. *Geobacter metallireducens*
(Courtesy: Childers, Ciufo and Lovley)

Miles below the earth's crust microbes survive without oxygen or sunlight by feeding on metals like iron and manganese. One of these microorganisms,

Geobacter metallireducens (Fig. 12), has an unusual survival tactic for life in the underworld: It uses a sensor to 'sniff out' metals. If metal is not nearby, *G. metallireducens* can spontaneously grow flagella -whip-like cellular propellers - to find new energy sources. In addition to using iron, the organism will use metals such as plutonium and uranium to metabolize food. *G. metallireducens* consumes these radioactive elements. In the case of uranium, microbes change the metal from a soluble to an insoluble form. The insoluble uranium drops out of the groundwater, thus decontaminating streams and drinking water. It remains in the soil and could then be extracted. For *Shewanella oneidensis* (Fig. 13) a microbe that modifies uranium chemistry, the pieces are coming together, and they resemble pearls that measure precisely 5 nanometers across enmeshed in a carpet of slime secreted by the bacteria. *Shewanella* also metabolizes toxic metals Scientists are researching the use of sulfate-reducing bacteria to convert toxic radioactive metal to inert substances, a much more economical solution.Science has only just begun to study the world's microorganisms. Just 0.1% of all microbes have been cultured, and who knows what other kinds of unique and essential properties we'll find when we start looking.

Fig 13. *Shewanella oneidensis* (Courtesy: Oak Ridge National Laboratory)

Microbes can help in degrading explosives too. Trinitrotoluene, TNT, is a problematic explosive that contaminates the soil in areas where ammunition is kept. Bacteria named *Clostridium bifermentans* (Fig. 14) is able to break down this contaminant. When provided with starch as energy source, the bacteria can break down the TNT through co-metabolism as a source of carbon. Toluene is one of the most toxic components of gasoline. Anerobic bacteria *Azoarcus tolulyticus* (Fig. 15) that degrade toluene are being studied as a possible way to bioremediate (clean up) such contaminated water supplies.

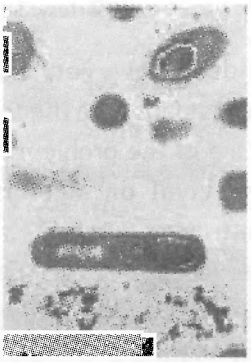

Fig 14. *Clostridium bifermentans* (Courtsey: Internet)

Pseudomonas is also one of the biggest contributors to cleaning up the environment. Scientists found that by feeding the contaminated area with

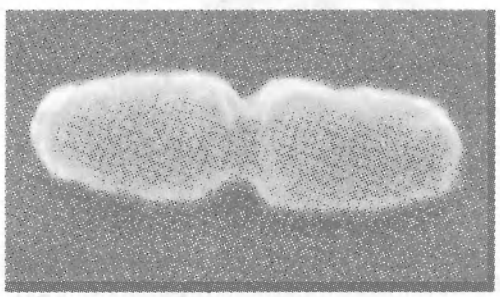

Fig 15. *Azoarcus tolulyticus* (Courtesy: Shirley Owens and Catherine McGowan)

oxygen and waste water, the bacteria present there were provided with the nutrients needed to flourish, thereby encouraging the break down of hydrocarbons within crude oil by *Pseudomonas*. The hydrocarbons that the bacterium feasts on are converted to Carbon dioxide and water.

Carbon, the main component of most diamonds, usually contains an isotope of light carbon (12C), which is utilized by some living organisms. Therefore, eclogitic diamonds with large amounts of the isotope 12C are believed to have an organic origin. These were formed from carbon near hydrothermal vents which was also utilized by the bacterial communities near the vents. Thus through time, heat and pressure they were able to turn the carbon along with the bacterial colonies into diamonds. It could be possible that those sparklers of your diamond may just be clumps of billion-year-old bacterial corpse.

Bacteria may form microbial 'jugnu' that emit visible light. Bacteria produce light in basically the same process called bioluminescence. 'Luciferase' - uses molecular oxygen and a protein that has a particular vitamin FMNH2 (reduced form of flavin mononucleotide) attached to it. 'Luciferase' causes oxidation reaction to occur between oxygen and vitamin leading to the conversion from FMNH2 to FMN. As this occurs, luciferin emits visible light. The color of light (orange, yellow, yellow-green, or blue-green) depends on the kind of luciferase and amount of oxidation of the vitamin attached to the luciferin.

Microbes are our great helpers ranging from domestic, industrial, social, and environmental. Bacteria can keep vegetables fresher. Even vegetables that are kept in airtight containers are prone to spoilage by psychrotrophs like *E. coli* and *Listeria*. Lactic acid bacteria are an alternative solution to this problem by producing natural acids like lactic acid and bacteriocin that prevent pathogenic bacteria like *Listeria* from growing in foods.

Bacteria are the best candidates to make chocolate. Chocolate comes from the seeds of the Cacao tree. The seeds come in pods and the only way to retrieve the seeds are to ferment them with yeasts and lactobacilli and Acetobacter. The *Lactobacillus* secretes an acid to help break apart the pod.

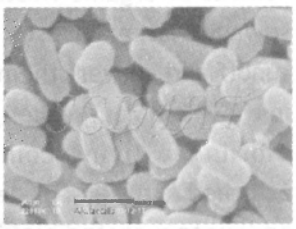

Fig 16. *Alcaligenes eutrophus* (Courtesy: SCIMAT 2001).

Alcaligenes eutrophus (Fig. 16) is a useful bacterium having the capability of making plastics. The bacterium is able to accomplish this feat because it has granules that are made of a fat-like polymer and not starch, like the granules of other bacteria. These plastics can be readily degraded and hopefully will pose less environmental threat.

In a novel study, researchers from University of Gothenburg have found that the cellulose produced by bacteria could be used to develop artificial blood vessels.

They say that bacterial cellulose carries a lower risk of blood clots than the synthetic materials currently used for bypass operations. Produced by a bacterium known as *Acetobacter xylinum* (Fig. 17), the cellulose is strong enough to cope with blood pressure and works well with the body's own tissue. This bacterial cellulose works very well in contact with the blood and is a very interesting alternative for artificial blood vessels.

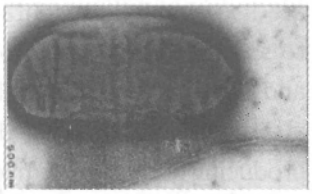

Fig 17. *Acetobacter xylinum* (Courtesy: Leonardo da Silva *et al.*)

Microorganisms are also being used for producing electricity from biomass. The microbial fuel cell (MFC) can take common sources of organic waste such as human sewage, animal waste, or agricultural runoff and convert them into electricity. In the microbial fuel cell, bacteria form a biofilm, a living community that is attached to the electrode by a sticky sugar and protein coated biofilm matrix. When grown without oxygen, the byproducts of bacterial metabolism of waste include Carbon dioxide, electrons and hydrogen ions. Electrons produced by the bacteria are shuttled onto the electrode by the biofilm matrix, creating a thriving ecosystem called the biofilm anode and generating electricity.

Microorganisms were the first living creature to start natural life on earth. Micropaleontologists discovered layers of sedimentary rocks, wavelike stromatolites in Great Lakes that are believed to contain microbial fossils. Some fossils are 3.5 billion years old, formed only one billion years after the creation of the Earth indicating that microbes are the earliest forms of life on Earth.

Recently, scientists at the Craig Venter Institute (JCVI) in Rockville Maryland has come up with artificial organisms that might one day produce new fuels, clean polluted water or speed vaccine production. Americans have named it as "Synthia". The creature is a bacterium named *Mycoplasma mycoides* JCVI-syn 1.0 (Fig. 18) and importantly, it reproduces on its own. This synthetic cell has its genome that was designed in the computer and brought to life through chemical synthesis, without using any pieces of natural DNA.

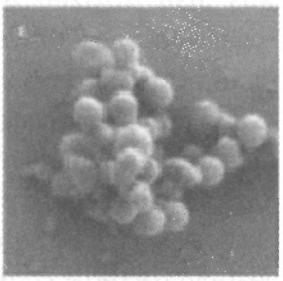

Fig 18. *M. mycoides* JCVI-syn 1.0 - *The JCVI* (Courtesy: Craig Venter Institute)

We should never underestimate the power of a microorganism. They are, just like that God cannot be seen through naked eye but we can feel their impact on us in various ways. Well, this is a world of microbes where we are living under their democracy.

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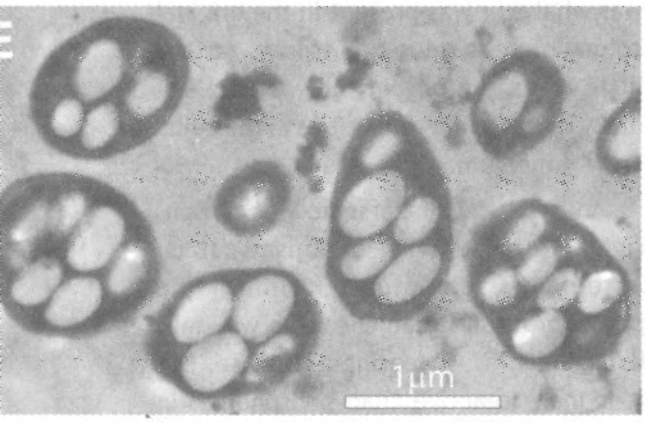
Arsenic-Eating Bacteria Opens New Possibilities for Alien Life

(This article is based on the research paper published by Henry Bortman in Astrobiology Magazine - Editor)

One of the basic assumptions about life on Earth may be due for a revision. Scientists have discovered a type of bacteria that thrives on poisonous arsenic, potentially opening up a new pathway for life on Earth and other planets.

If you thumb through an introductory biology textbook, you'll notice that six elements dominate the chemistry of life. Carbon, hydrogen, oxygen and nitrogen are the most common. After that comes phosphorus, then sulfur. Most biologists will tell you that these six elements are essential; life as we know it cannot exist without them.

The recent discovery by Felisa Wolfe-Simon of an organism that can utilize arsenic in place of phosphorus, however, has demonstrated that life is still capable of surprising us in fundamental ways. The results of her research appeared in the December 2 issue of the journal *Science*.



Transmission electron micrograph shows a strain of the arsenic-eating bacterium called GFAJ-1 (Credit: Science/AAAS)

The organism in question is a bacterium, GFAJ-1, cultured by Wolfe-Simon from sediments she and her colleagues collected along the shore of Mono Lake, California. Mono Lake is hypersaline and highly alkaline. It also has one of the highest natural concentrations of arsenic in the world.

Life-form's toxic food

On the tree of life, according to the results of 16S rRNA sequencing, the rod-shaped GFAJ-1 nestles in among other salt-loving bacteria in the genus *Halomonas*. Many of these bacteria are known to be able to tolerate high levels of arsenic.

But Wolfe-Simon found that GFAJ-1 can go a step further. When starved of phosphorus, it can instead incorporate arsenic into its DNA, and continue growing as though nothing remarkable had happened. "So far we have showed that it can do it in DNA, but it looks like it can do it in a whole lot of other biomolecules as well", says Wolfe-Simon, a NASA

research fellow in residence at the USGS in Menlo Park, California.

"It is the first time in the history of biology that there has been anything found that can use one of the different elements in the basic structure", says Paul Davies, the Director of BEYOND: Center for Fundamental Concepts in Science at Arizona State University in Tempe, Arizona.

"Wolfe-Simon's finding can only reinforce people's belief that life can exist under a much wider range of environments than hitherto believed" Davies said. He sees the discovery of GFAF-1 as "the beginning of what promises to be a whole new field of microbiology".

Michael New, NASA's astrobiology discipline scientist, agrees. "The discovery of an organism that can use arsenic to build its cellular components may indicate that life can form in the absence of large amounts of available phosphorous, thus increasing the probability of finding life elsewhere", he said. "This finding expands our understanding of the conditions under which life can thrive, and possibly originate, thereby increasing our understanding of the distribution of life on Earth and the potential habitats for life elsewhere in the solar system".

In case you're not impressed yet, here's a quick refresher:

The DNA molecule is shaped like a spiral ladder. The 'rungs' of the ladder are comprised of pairs of nucleotides, which spell out the genetic instructions of life. The sides of the DNA ladder, referred to as its backbone, are long chains of alternating sugar and phosphate molecules. A phosphate molecule contains five atoms: one of phosphorus, four of oxygen. No phosphorus, no phosphate. No phosphate, no backbone. No backbone, no DNA. No DNA, no life.

GFAJ-1 apparently didn't read the manual.

When Wolfe-Simon starved GFAJ-1 cells of phosphorus, while flooding them with arsenic, far more than enough arsenic to kill most other organisms, it grew and divided as though it had been offered its favorite snack.

Arsenic-loving bacteria

Wolfe-Simon, with assistance from colleagues in Ron Oremland's group at the USGS in Menlo Park, California, has grown generation after generation of these bacteria.

The bacteria continue to swim around in their test tubes, unconcerned, despite the fact that, since Wolfe-Simon first collected them more than a year ago, the only phosphorus they have had access to was whatever was present in the original colony of cells, plus tiny traces, far too little to sustain ongoing growth and cell division, present as impurities in the cells' growth medium.

And you thought arsenic was poison, right? To most living organisms, it is. Arsenic is chemically similar to phosphorus, so it can sneak its way into living cells, as if wearing a disguise. But it is more reactive than phosphorus, in ways that tend to rip apart life's essential molecules. DNA, for example.

Somehow, GFAJ-1 appears to have found a way to overcome this problem.

As a control, a second culture of GFAJ-1 cells was fed phosphorus instead of arsenic. They, too, grew and divided. GFAJ-1 seems to be able to switch back and forth, depending on how much phosphorus is available.

"I have no idea how they're doing and what they're doing", Wolfe-Simon says.

Once she realized that GFAJ-1 was capable of growing when starved of phosphorus, Wolfe-Simon set about finding out in more detail what was going on inside its cells. Could it be, perhaps, that she had found a microbe that, rather than incorporating arsenic into its biological structures, was instead exceptionally good at recycling extremely limited amounts of phosphorus?

DNA holds the key

Wolfe-Simon and her colleagues used several different experimental techniques to find an answer.

Data produced by mass-spectrometry methods known as ICP-MS and NanoSIMS, showing the distribution of various chemical elements within GFAJ-1 cells, revealed a clear difference between cells grown with arsenic and those grown with phosphorus. Those grown with arsenic were loaded with the stuff, but contained very little phosphorus. In cells grown with phosphorus, the opposite was true.

By introducing radioactive arsenic into the growth medium of some of the microbes, Wolfe-Simon learned that about one-tenth of the arsenic absorbed by the bacteria ended up in their nucleic acids.

To confirm that this arsenic was being incorporated into DNA, she used a well-accepted molecular biology technique known as gel purified DNA extraction to isolate and concentrate DNA from GFAJ-1 cells.

The value of this technique is that it ensures that no other material from the cell comes along for the ride. NanoSIMS measurement of these concentrated DNA extractions showed that arsenic was indeed present in their DNA.

Still further evidence came from the use of a technique known as micro extended X-ray absorption fine structure spectroscopy (EXAFS). EXAFS can provide information about the structure of molecules by probing how its internal chemical bonds respond when stimulated by a beam of light.

Within the DNA extracted from GFAJ-1 cells starved of phosphorus, it showed arsenic bonded to oxygen and carbon in the same way phosphorus bonds to oxygen and carbon in normal DNA.

In other words, every experiment Wolfe-Simon performed pointed to the same conclusion: GFAJ-1 can substitute arsenic for phosphorus in its DNA. "I really have no idea what another explanation would be," Wolfe-Simon said.

Skepticism over discovery

But Steven Benner, a distinguished fellow at the Foundation for Applied Molecular Evolution in Gainesville, Fla., remains skeptical. "If you replace all the phosphates by arsenates, in the backbone of DNA", he said, "every bond in that chain is going to hydrolyze [react with water and fall apart] with a half-life on the order of minutes, say 10 minutes".

"So if there is an arsenate equivalent of DNA in that bug, it has to be seriously stabilized by some as-yet-unknown mechanism", Benner said.

Benner suggests that perhaps the trace contaminants in the growth medium Wolf-Simon uses in her lab cultures are sufficient to supply the phosphorus needed for the cells' DNA. He thinks it's more likely that arsenic is being used elsewhere in the cells, in lipids for example.

"Arsenate in lipids would be stable," said Benner, and would "not fall apart in water". What appears in Wolfe-Simon's gel-purified extraction to be arsenate DNA, he added, may actually be DNA containing a standard phosphate-based backbone, but with arsenate associated with it in some unidentified way.

The discovery of GFAJ-1's unusual abilities suggests a number of avenues for further research. One obvious one is to see whether any other organisms can perform similar biochemical tricks. Wolfe-Simon would be very unlikely to have just found the only arsenic life-form on Earth on the first try. "So it's got to be the tip of a very large iceberg", Davies said.

And indeed, Wolfe-Simon said she is already growing "14 or so other isolates from Mono Lake on a phosphorus-free diet high in arsenic". They may be the same organism she's already identified, they may not. "I don't know anything else about them, except that they grow under similar conditions". Meanwhile, Wolfe-Simon has ordered stock cultures of several previously identified *Halomonas* organisms, close relatives of GFAJ-1 on the genetic tree, all known to be arsenic-tolerant. She plans to test whether they, too, can survive in a phosphorus-free environment.

Ron Oremland and Felisa Wolfe-Simon collect samples of lakeshore mud from Mono Lake's 10-Mile Beach (Credit: ©2009 Henry Bortman)

She's also interested in finding out whether GFAJ-1 is actively employing its arsenic-incorporating ability in its natural state. "You want to know, is this biology being done in the environment or is it some very bizarre thing, like a hat trick [that it does only] in the lab".

And Davies suggests it would be interesting to search in 'an environment that has very little phosphorus and lots of arsenic' for an organism that requires arsenic to survive, 'for which phosphorus would be the poison'. Mono Lake, he pointed out, 'has phosphorus as well arsenic'. These and other investigations will help to clarify how extensive a role arsenic plays both within GFAJ-1 and in terrestrial biology as a whole.

But while some scientists may reserve final judgment about Wolfe-Simon's conclusions until further details can be clarified, even Benner concedes that 'If that organism has arsenate DNA, that is a world-class discovery'.

Wolfe-Simon's research is funded by the NASA Exobiology/Evolutionary Biology Programme.

Team Science India

GRASSES, THE ENERGY SOURCE OF FUTURE?

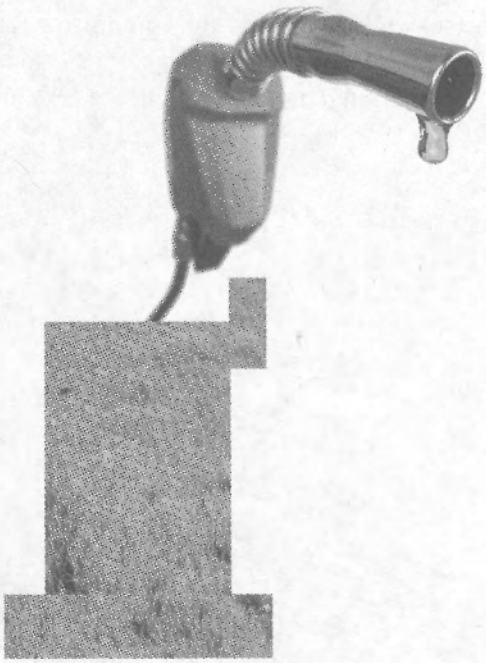
Dr. M.S. Kiranraj

As the World now faces fuel crisis, biofuels remain one of the most technically promising alternatives to oil. What many do not realize is that the grasses laying around the yard could actually be used as fuel for your motor vehicle and other engine types? The actual name for this biofuel is called 'grassoline' and it has caught the interest of environmentalists all over the world now. In 2009, a combined research from University of Massachusetts and Michigan State University of U.S. successfully developed a new technology to produce biofuel from grasses. The key is to convert cellulosic biomass into fuel.

The cellulosic biomass comprises woods, grasses and inedible stems of plants. Fuel made out of this biomass - grassoline - could also come from wood residues such as sawdust and construction debris, to agricultural wastes such as maize (*Zea mays*) or sugarcane (*Saccharum officinarum*) culms. All fast-growing perennial grasses can be used as "energy crops". Huge amounts of cellulosic biomass from wasteland grasses can be sustainably harvested to produce fuel.

Cellulosic biofuel could reduce the trust on petroleum without the problems associated with ethanol from corn or sugarcane. Ethanol is environmentally safer than gasoline and diesel, and is currently being used and tested to fuel

Ethanol is environmentally safer than gasoline and diesel, and is currently being used and tested to fuel vehicles and other engines. Instead of producing ethanol from corn or sugarcane (edible part) via. fermentation, the new technique could produce grassoline from cellulosic (non edible) biomass.



'Grassoline station'

Cymbopogon caesius

vehicles and other engines. Instead of producing ethanol from corn or sugarcane (edible part) via. fermentation, the new technique could produce grassoline from cellulosic (non-edible) biomass. Researchers say, using grasses and other natural vegetation in order to power engines is something that is being done to lower the amount of greenhouse gases being leaked into the atmosphere.

According to the recent survey in U.S., the cellulosic biomass could produce more than biomass can be converted to any type of fuel - ethanol, ordinary gasoline, diesel or even jet fuel. Projections estimate that the global supply of cellulosic biomass has an energy content equivalent to between 34 billion to 160 billion barrels of oil per year, numbers that exceed the world's current annual consumption of 30 billion barrels of oil.

Grass pellets, the source of alternative renewable energy!

Burning grasses for energy has also been a well-accepted technology in Western countries.

Phragmites karka

'Grass pellets' have great potential as a low-tech, small-scale, renewable energy system that can be locally produced, locally processed and locally consumed, while having a positive impact on rural communities. Burning grass pellets as a biofuel is economical, energy-efficient, environmentally friendly and sustainable. Grass biofuel pellets are much better for the environment because they emit up to 90 percent less greenhouse gases than do oil, coal and natural gas.

Any mixture of grasses can be used, cut in mid-to late summer, left in the field to leach out minerals, then baled and pelleted. Drying of the hay is not required for pelleting, making the cost of processing less than with wood pelleting. It is true that pelletized grass has the potential to be a major affordable, unsubsidized fuel source capable of meeting home and small business heating requirements at less cost than all available alternatives.

Across the world, there are over 80 potential energy plant species being considered and used for fuel and energy production. Theses include shrubs, trees, grasses (including cereals), reeds etc. Some produce biomass as the by-products of food production (ground nut, corn, sugar cane, coconut palm etc.), but a large proportion are grown specifically as dedicated biomass energy crops. Many grass biomass crop species originate from tropical and sub-tropical regions of the world.

Some promising perennial grasses of India, which can be used as 'energy crops' are *Arundo donax, Apluda mutica,*

Arundo donax

Bamboos, *Chrysopogon* spp. (origin: India), *Coix* spp., *Cymbopogon* spp. (origin: India), *Eleusine coracana* (origin: Africa and India), *Heteropogon* spp. (origin: India), *Saccharum* spp. (origin: India), *Sorghum* spp. (origin: India), *Miscanthus* spp., *Pennisetum* spp, *Panicum* spp., *Phragmites* spp., *Themeda* spp. (origin: India), *Thysanolena latifolia* (origin: India), *Triticum* spp., *Zea mays,* etc. In the country, the productive level of energy from these grasses needs to be well studied.

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State of phytoplankton, zooplankton and Krill of the Fishing Area 58 of Indian Ocean sector of Southern Ocean in 1995-96

Dr. Vijayakumar Rathod

Abstract

Antarctic marine ecosystem consists of the assemblage of plants, animals, ocean, sea ice, and island components south of Antarctic Convergence. Biomass and various productions play a key role in the polar ecosystem, and factors (light, temperature, nutrients, water column stability, advection, grazing, and sinking) that regulate production, and population growth. Even though this marine ecosystem display extreme inter-annual variability in both biomass and production, persistent spatial gradient in biomass and growing season is characterized by episodic blooms. This high inter-annual variability at the base of the food chain influences organisms at all trophic levels.

The Southern Ocean is characterised by large seasonal variability in its environmental conditions which influence the global climate. This has led to understand, describe and, forecast the state of Southern Ocean ecosystem and to quantify the changes in the ocean's physical, chemical and biological properties, processes and their driving mechanisms operating in this region. These days these is a growing interest in the exploration of the Southern Ocean. A critical element of the programme of the First Indian Krill Expedition (FIKEX) involves an observation aimed at assessing the variables in phytoplankton, zooplankton and Krill's of the fishing area 58 of Indian Ocean sector of Southern Ocean in 1995-96.

Introduction

The Antarctic marine ecosystem is globally significant (Harris and Stonehouse, 1991). Mounting evidence suggests that the world climate is changing and that polar regions with their associated ecosystems, may be especially sensitive to this change. Ecosystem research in the marine system (Fraser *et al.*, 1992), and paleoecological records from Antarctic (Emslie, 1995) show that ecological transitions have occurred in response to climate change. Primary production follows closely the distribution of phytoplankton biomass measured as chlorophyll a (chl-a) concentration, and published values show a wide range of spatial and temporal variability (Smith *et al.*, 1996). Concentrations are greatest near shore with an onshore/offshore gradient of decreasing biomass towards

the continental slope that follows a gradient in bottom topography and physical and optical properties (Smith *et al.*, 1996). While many physical and biological factors (e.g., light, temperature, nutrients, water column stability, advection, grazing, sinking) have been hypothesized as controls of cell and population growth, it is likely that no single factor dominates, and environmental variability can significantly influence these various factors. Sea ice coverage also shows high spatial and temporal variability (Stammerjohn and Smith, 1996) which has important implications for the marine ecosystem (Smith *et al.*, 1998). Therefore, a central hypothesis and retreat of sea ice is a major physical determinant of spatial and temporal changes in the structure and function of the Antarctic marine ecosystem.

Results and Discussion

Phytoplankton are microscopic plants that form the base of the aquatic food web, occupying a position similar to that of plants on land. There is a wide variation in the size of phytoplankton, with the largest species being members of a group called diatoms while smaller species are members of a group called flagellates. They use light to produce organic matter from nutrients dissolved in marine waters. The growth rate at which new organic matter is produced depends on temperature and the abundance of light and nutrients. The phytoplankton constitute the primary food source to zooplankton. In most marine waters, phytoplankton undergo a spring-summer explosion in abundance called a bloom.

The dominant zooplankton in the fishing area 58 of the Indian Ocean sector are copepods. They represent the critical link between phytoplankton and larger organisms. Young copepods (nauplii) are the principle prey of young fish while the older stages (copepodites) are eaten by large fish, such as juvenile and adult capelin fish. The description of the cycle of nutrients on the Antarctic waters aids in understanding and predicting the variability of plankton populations in space and time. An understanding of the plankton cycles will, in turn, aid in assessing the health of the marine ecosystem and its capacity to sustain fisheries.

A special cruise was conducted during December, 1995 to March, 1996, on FORV Sagar Sampada. The investigations of the First Indian Antarctic Krill Expedition (FIKEX) have importance in basic and applied fields. From the study, new information is now available on the role and magnitude of marine biota processes in the physiological, chemical and biological functioning of the marine living resources and their ecosystem.

The study area which lies between latitude 56° to 61° 17' S and longitude 30° to 40° E (Fig. 1). The study was undertaken to gather first-hand information on phytoplankton, zooplankton species composition, abundance, distribution exploitation, and post-harvest technology of Krill and fish

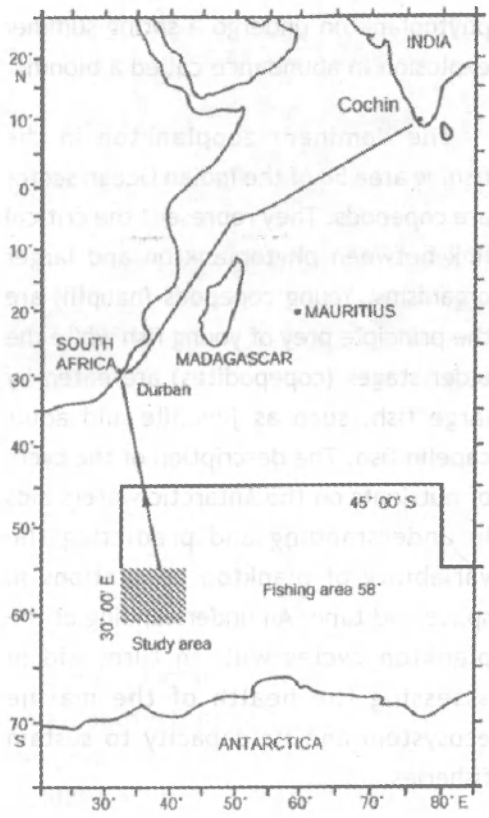


Fig. 1. FIKEX Cruise study area

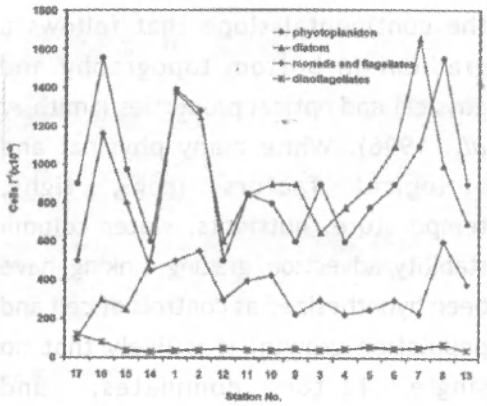


Fig. 2. Mean water column concentrations of the major phytoplankton groups at stations occupied during the FIKEX cruise. The X axis does not represent distance, but stations are arranged in order of increasing latitude, with Stn. 17 at 56° S, and Stn. 13 at 61° 17'.

trends from Antarctic water of the Indian sector of the Southern Ocean. Some of the major highlights of our studies are follows.

Phytoplankton

Diatom dominate the phytoplankton in this region and their numbers generally increases southward with peaks of abundance in both north and south of Antarctic waters (Fig. 2). Dinoflagellates, flagellates and "monads" occur in highest concentration north of the Polar Front. Their numbers are somewhat reduced towards south. Various diatom assemblages are characteristics of different latitudinal zones. North of and in the vicinity of the Polar Front are rich in the *Nitzschia* and *Pseudonitzschia* group of species. South of Polar Front *Nitzschia nana* and *Dactyliosolen tenuijunctus* dominate. Of the species observed, the common feature to both the present and previous study reveals that the predominance among the diatoms are *Fragilariopsis kerguelensis* and *Thalassionema nitzschioides* were always present, while *Pseudonitzschia* spp. were in large numbers. These dominant diatoms are known to have somewhat different biogeographical distributions (Rathod, 2007).

The Antarctic water is unique in that it has continually high concentrations of major plant nutrients but low phytoplankton biomass. Global climatologies indicate that the Antarctic water region with low surface temperatures, weak density stratification, little summer time surface solar irradiance, and strong wind stress. These physical phenomena act to limit growth rates of the phytoplankton community.

Zooplankton

Zooplankiton biomass values ranged from 9,79 to 303.62 ml 100 m^{-3} ($\bar{x}$ = 142.14 ± 77.02) (Fig. 3). High standing stock

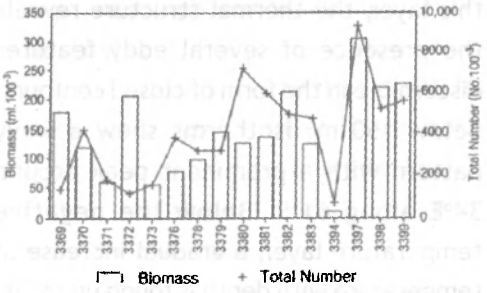


Fig. 3. Zooplankton biomass and total number at different stations

values were recorded in the study area, where copepods, chaetognaths, euphausiids and salps were the dominated taxa. Copepods and chaetognaths formed the major constituents of zooplankton community and comprised more than 70% of zooplankton catch. Copepod biomass was 77% of its summer level. During surveys, the large and abundant *Calanoides acutus* and *Rhincalanus gigas* dominated the copepod biomass and, with several other species, showed a marked downwards seasonal migration out of the top 250 m layer in winter. Swarms of Krill and salps were observed during the study period (austral summer), which were the prime cause for high standing stock of zooplankton. The prevailing physico-chemical parameters with rich food supply were important factors influencing the geographical distribution of different zooplankton groups (Rathod, 2005).

Zooplankton range in size from 1 mm of copepods to about 4 cm of krill. They are eaten by all species of fish at some time in the fishes life cycle. There is evidence that the abundance of some species of zooplankton can influence recruitment and growth of fish such as cod, herring and capelin. The most copepods to fish are *Calanus finmarchicus* and *Pseudocalanus* spp. whereas *Meganyctiphanes norvegica* is the most important Krill species. The eggs and young ones of zooplankton are eaten by the youngest stage of fish and as the fish grow they feed on larger zooplankton. Many fish species also feed heavily on adult Krill. The study revealed that the present investigation site falls under potential Krill fishing ground.

Zooplankton trends in Fishing Area 58 region

Copepod biomass was 77% of its austral summer level. Copepod *Calanoides acutus, Rhincalanus gigas, Calanus finmarchicus*, *Pseudocalanus* spp. and *Meganyctiphanes norvegica* dominated the copepod during austral summer and fall and remain in the deep water until the breeding season in the late winter and early spring. It is belived that the size of the fall population of *C. finmarchicus* in Antarctic waters is a good indicator of the size of the previous spring and summer population on the Scotian Shelf (Sameoto and Herman, 1990).

The observed trends are attributed mainly to the variation in the position of the Polar Front during the summer and winter. This resulted in the greater influence of sub-Antarctic water around Indian Ocean sector of the Southern Ocean and the displacement of Antarctic species.

Globally scientist concern over the impacts of climate change intensifies and a clear picture of major changes in plankton ecosystems over recent decades emerges. Changes in plankton abundance, community structure, timing of seasonal abundance and geographical range are now well documented, as are knock-on effects on commercial fisheries. However, it remains to be seen how the ocean biota itself might influence the pace of climate change.

Temperature Profile

Temperature Profile of study locations are shown below. The surface temperature varied from 0.85 to 1.65°C along 61°S, the corresponding variation in temperature for 60°S and 59°S are 1.32 to 1.80°C and 1.05 to 2.46°C, respectively

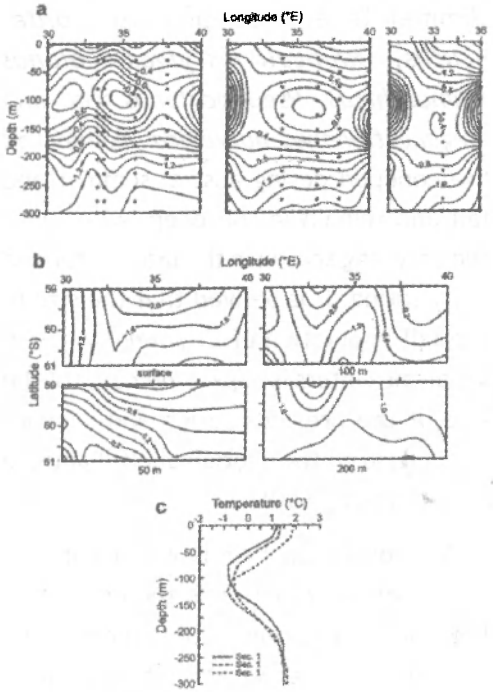


*Fig. 4. **a.** Variations in temperature at vertical level. **b.** Spatial distribution. **c.** Mean vertical temperature profile*

(Fig. 4 a). An important feature of the vertical thermal structure is the occurrence of a negative temperature (-0.03 to -1.58°C) layer of about 60-80 m thickness in the depth range 50-150 m. In this layer, the thermal structure reveals the presence of several eddy features discernible in the form of closed contours. Below 150 m, isotherms show a wavy pattern with a prominent peak around 34°E along 61°S. Below the negative temperature layer, a gradual increase of temperature with depth is found up to 300 m, where the values range between 1.4 and 1.8°C (Shirodkar *et al.*, 1999)

The spatial distribution of temperature at four levels of surface, viz. 50 m, 100 m, 200 m is shown in Figure 4 b. The sea surface temperature varied between 1 and 2.2°C with a warm core around 59° S, 35° E. At 50 m depth, isotherms indicate the presence of cold polar waters with temperatures ranging from 0.8 to 1.2°C with relatively cold water occurring in the south western region. At 100 m depth, sub-zero temperature with a core temperature of -1.6°C were noticed around 61° S, 30° E. However, a warm core cell is evident between 33° and 34°E. In general, the spatial distribution of temperature is charaterised by cold intermediate layer trapped relatively warm upper and lower layers.

Mean temperature profile along 61, 60 and 59°S (Fig. 4 c) highlights three distinct layers of the water column. The near surface layer having thickness of about 50 m with positive temperature (0-2°C) ; the intermediate layer (50-150 m) with

negative temperature (-1.6 to 0.2°C) and third layer (150-300 m) characterised by positive temperature (0-2°C).

The data express that zooplankton living in the top 50 m are exposed to relatively high temperature with wide fluctuations. Planktons also vertically migrates between day and night from deep water into the upper 50 m and would spend about half of their life in colder waters and therefore likely would have slower growth rates.

Acoustic Data

Acoustic data are good indicators of changes in Krill abundance both across shelf and open waters of the study period. The levels of backscattering at 120 kHs is evident for good patchiness and distribution of krill biomass (Fig. 5). The

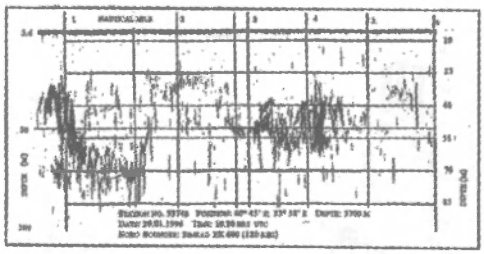
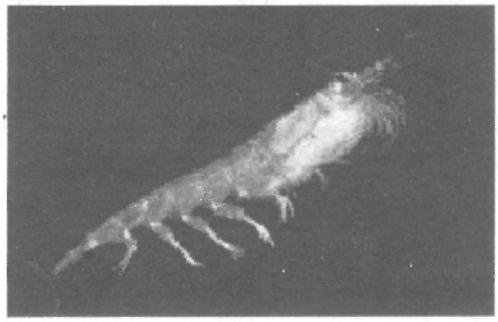


Fig. 5. Echogram representing Krill swarm

Krill acoustic index in the fishing area 58° indicated a lower biomass. The maximum value of the mean density of Krill biomass over a distance of 1 nm was equal to 16,9 t $km_{.2}$. Average of absolute deviations of Krill biomass densities from the mean value along the current transects was 0.64, which indicate a high degree of patchiness in distribution (FIKEX Cruise Report 1996).

Krill



It has been ascertained that Krill migrations occur between sea surface and a depth of about 100 m. Availability of food is the key factor affecting both seasonal and annual changes, and leads to Krill migration. Under food feeding conditions the amplitude is maximal, and the migration cycle approaches 24 h. Adult individuals exhibit 24 h migration, whereas juveniles show lower migration, and their submergences is shallower. Water stratification may also affect Krill distribution in the water column, and in certain conditions may lead to limitation of migration range. Krill migrations show both, seasonal and annual changes related mainly to food availability expressed as the concentration of chlorophyll a (Rathod, 2005). Average of absolute deviations of krill biomass densities from the mean value along the transects was 0.64, which indicate a high degree patchiness in distribution. The patchiness in distribution of biomass is evident from Figure 6 a and trends in krill density distribution in sub-area between lat 60° and 61° 17' S Figure 6 b. It seems that krill for Krill, as planktonic filtrator, the staying in surface waters rich in phytoplankton should be most profitable. However, during the day Krill clearly

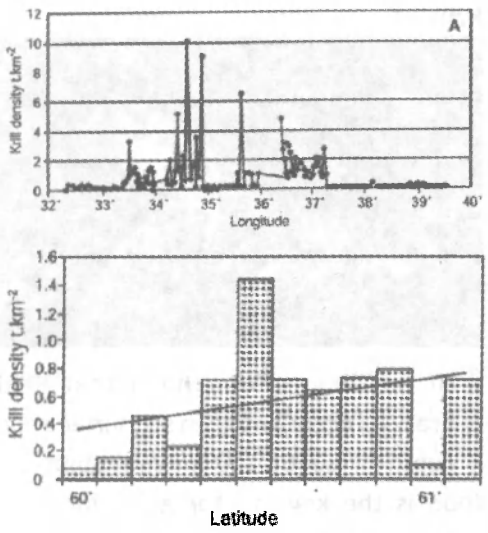
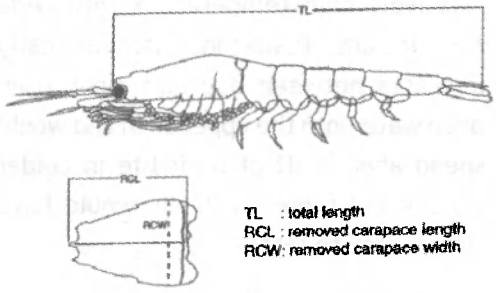


*Fig. 6. **a**. Patchiness in distribution of biomass. **b**. Krill density distribution in sub-area between lat 60° and 61° 17' S.*

avoids shallow depths. A tentative hypothesis is proposed, that Krill migration behaviour has developed during the last several tens of years as an adaptative form enabling a decrease of mortality caused by surface predators such as seal and birds, whose numbers increased many times after extinction of whales.

The data of the FIKEX expedition have been used for the evaluation of energy flow through Krill aggregation and through three species of Copepoda : *Calanoides acutus, Calanus propinquus* and *Rhincalanus gigas*. It was evaluated that the energy requirement of Krill and copepods in austral summer constituted only about 1.2% of the phytoplankton production. The depth distribution as well as the mean values of Krill depth were similar to those of open water both in this study and reported earlier in literature.

Determination of sex, body measurements and its variations in *Euphausia superba* Dana



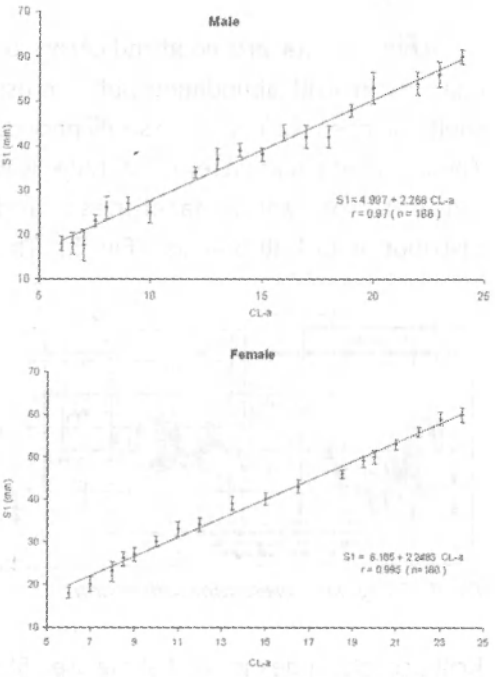


*Fig. 7. **a**. Measurements of Euphausia superba Dana. TL : Total Length. RCL: Removed Carapace Length. RCW : Removed Carapace Width.*

***b**. Standard length (S1) to carapace length (CL-a) relationship of sexually Immature males compared with raw data (+ 1 standard deviation for all Males animals*

***c**. Standard length (S1) to carapace length (CL-a) relationship of sexually Immature females compared with raw data (+ 1 standard deviation for all Females animals).*

Regression functions of total length on removed carapace length and width were calculated for Antarctic Krill *Euphausia superba* Dana for both sex and maturity stages (Fig. 7). However, this article allows a more precise estimation of the proportion of the diet made up by female Krill, in addition to increased accuracy of estimation of their size. Samples collected from scientific net during our expedition and collected at South George were compared. The length-frequency distribution of each maturity/sex stages composition between nets were also compared (Rathod, 2009).

Variations were found on various body length measurements made on freshly captured *Euphausia superba* Dana (Fig. 8). All functions were calculated to describe the relationship of various length measurements to one another for fresh

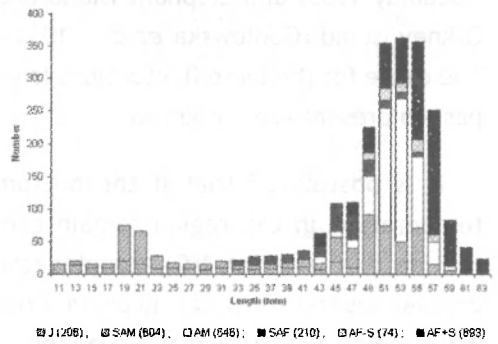


Fig. 8. Length-frequency distribution of each maturity/sex stage of krill from net-caught samples taken from fishing area 58 of Indian Ocean sector in Southern Ocean. Sample sizes are given in parenthesis

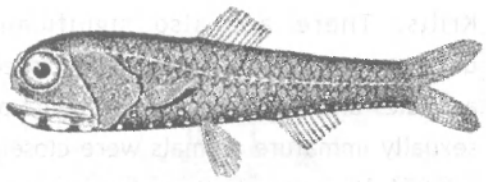
J : *Juvenile*
SAM : *Sub-adult male*
AM : *Adult male*
SAF : *Sub-adult female*
AF - S. : *Adult female without spermatophore*
AF + S. : *Adult female with spermatophore*

Krills. There are also significant differences among the group distinguished as males and females. Measurements of sexually immature animals were closely related. Variations in the relationship of standard length to carapace length were found for both mature males and females and can be attributed to the presence of ripe ovaries in mature females and difference in growth rates of mature males (Rathod, 2009).

Krill and pelagic fish trends in the study area

Acoustic data indicate a close relationship between the fish and krill in fishing area 58 Indian Ocean sector. The data collected have shown a close relationship of backscattering at 120 kHs. The 120 kHs frequency data reflects the concentration of pelagic fish in the region and also is evident for accurate estimate of the Krill concentrations (Fig. 5).

Silver hake and redfish, the two dominant pelagic species, feed primarily on Krill in the Basin (Waldon, 1988). Our study reveled that 120 kHs backscatring, indicating the krill stock had increased from the low values (Rathod, 1996). Among the pelagic fishes, Lantern fishes belonging to family Myctophidae were represented by four species, *Gymnoscopelus nicholsi, Electrona Antarctica, Gymnoscopelus braueri* and *Protomyctophum normani* and of family Anotopteridae - daggertooth - one species as *Anotopterus pharaoh* Zugmayer are caught in the net (FIKEX Report 1996).



Lantern fish

Summary

In the Antarctic, living things and their relationships in the food web are greatly influenced by the physical environment. This includes factors such as the annual extent of ice cover, currents, winds, temperature, and other weather and climate conditions.

The food web itself is a relatively simply one, consisting of many species in very few trophic levels. The primary producers in the Antarctic food web are phytoplankton. The primary consumers are zooplankton. A key species of zooplankton is Krill, on which animals of all other trophic levels depend, some directly, others indirectly.

The Antarctic marine food web is made up on phytoplankton (microscopic plants), zooplankton (microscopic animals), and a large number of secondary and tertiary consumers and some scavengers. Animals at higher trophic levels include fish, penguins, other birds, seals, and whales.

A description of the seasonal patterns in the distribution of phytoplankton and zooplankton provides important information about organisms that form the base of the marine foodweb. An understanding of the production cycles of plankton, and their inter-annual variability, is an essential part of an ecosystem approach to fisheries management.

Outlook

The Polar Front open water has been influenced by normally cold bottom temperatures in recent years and it is possible that this cold water has effected the size of the Krill population in the area. Long-term time series data only can reveal that the levels of Krill in the region were lower in the 1990s than in the past period or will emerge in future based on bottom temperature.

Zooplankton samples and acoustic index showed that there was a gradual increase in both Krill and fish population in the basin followed by a steep decline in their population size in 1996. The Krill abundance increased in 1996 to levels observed between Weddel sea (Daly and Macualay 1983) and Elephant Island and Orkney Island (Godlewska *et al.*, 1991). The cause for the large fluctuations from past to present are not known.

It is postulated that if the bottom temperature in the region remain cool (i.e. in the range of 1°C), zooplankton populations and possibly Krill populations will remain low in the Indian Ocean sector region. It is within this context of a highly variable physical environment that we consider the spatial and temporal variability found in Antarctic production.

Acknowledgement: Author is thankful to Dr. Satish R. Shetye, Director, National Institute of Oceanography, Goa and Secretary, DOD, New Delhi for providing

facility and constant encouragement. My sincere thanks to captain and crew members of FORV Sagar Sampada for their help in collection of the samples.

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Strategies and Approaches for Soil and Water Conservation in Hill Ecosystem

Lala Iswari Prasad Ray

Introduction

Soil and water are the two critical resources for agricultural production, hence it is very much important to manage them in a sustainable way. Survival and well-being of a nation depend on sustainable development i.e. satisfying present needs and values of all interest groups without foreclosing future options. Erosion by water, wind and other agencies is one of the most serious problems affecting land all over the world. It probably began when man first learnt to till the soil. Out of total area of India of about 329 M ha, a proportionate area is under degradation by various means viz. water and wind erosion (150 M ha), salinity and alkalinity (8 M ha) and river action and other factors (7 M ha). Soil erosion causes rapid fertility depletion, damages crops by sedimentation and raising stream beds/river channels by siltation which causes flash floods and limits discharge capacity, irrigation and navigation. Soil and water conservation form an integral part of any strategy for management of natural reserves on the entire ecosystem, more so in hilly regions.

Farming practices in hilly region

The agricultural system in hilly region can be broadly classified in to two distinct types, viz. settled farming practices in the plain, valley, foothills and terraced slopes, and shifting cultivation practices in the hill slopes. Excessive precipitation causes very rapid runoff in steep slopes resulting in heavy soil loss as well as siltation of river bed. The shifting cultivation practices, *Jhum* and *Bun* type of land preparation along the slopes increase the intensity of the problems. It may also lead to catastrophic flood hazard in plains and also dangerous landslides. Furthermore it promotes excessive leaching losses causing poor base status and high soil acidity leading to detrimental environment for nutrient availability of common agricultural crops. All this underscores the need for a scientific and technical approach towards soil and water management in the region.

Major Jeopardy

Shifting cultivation: Shifting cultivation (*Jhum/Podu*) is regarded to be the first step in the transition from food gathering or haunting to food production and believed to have originated in the Neolithic period around 7000 BC. Agriculture under this system is practiced on steep slopes after removing the forest vegetation and thus, is susceptible to excessive soil erosion. Beside this, washing of fertile topsoil and exposure of rocks due to soil wash as a result of shifting cultivation have been reported. Land to be brought under shifting cultivation is selected during December/January and then it is cleared by way of cutting the forest vegetation, allowing it to dry in the field, setting on fire the dried vegetation in March/April and clearing the slope from remaining trash. All kinds of essential crops like rice, maize, tapioca, colocasia, beans, etc., are planted in intimate mixture during the first year and in the second year, usually rice is grown as a single crop. The lands are abandoned after 2 to 3 years of cultivation for natural build up of soil fertility and regeneration of vegetation. The farmers then select fresh site and repeat the same process of cultivation.

Bun method of cultivation: Cultivation of tuber crops and vegetables on series of beds formed on slopes is widely practiced in the hilly region. The system locally known as 'BUN' method of cultivation, involves putting of dried vegetation, mainly Khasi pine (*Pinus kesiya*) along with existing weeds like *Sataria gluaca*, *Imperata cylindrica* and *Lantana camara* in the form of raised beds along with slope, covering the same with soil collected from surrounding, burning of the covered vegetation and planting of tuber crops. When sufficient dried vegetation is not available, the beds are made of soil only. Though good crop yield is obtained, the system leads to huge soil loss.

Glimpses of Northeast India

North East region of India constitutes of a total geographical area of 26.2 M Ha with more than 39 million population. The entire region is connected with the rest of India only through a narrow corridor in north Bengal, having an approximate width of 33 km on the eastern side and 21 km on the western side. This narrow corridor is popularly known as *'Siliguri neck'* or *'Chicken's neck'*. Out of this total geographical area 28.3% has an elevation of more than 1200 m, 17.9% between 600-1200 m and about 10.8% between 300-600 m above mean sea level. This region had about 72% area under hill ecosystem. The region receives high rainfall and therefore clothed with diverse and dense vegetation. Agricultural operations are carried out up to 3600 m altitude and on slope up to 60%. This region mostly comes under *warm per-humid eco-region* with brown and red hill lateritic soils (Agro Ecological Zone No. 16 and 17), with an annual precipitation of 1600 to 4000 mm and Potential Evapo Transpiration (PET) greater than 1100 mm. Cropping system in this region is predominantly rice based except in Sikkim, where maize based system is dominant.

Factors causing soil and water loss

Among all the factors causing soil and water loss, expanding population, mis-utilisation of natural resources etc. are man made. Following are some of the salient adverse effects of erosion:

1. Degradation of agricultural land
2. Forest degradation
3. Drop in water supply
4. Damage to water bodies
5. Adverse effect on communication
6. Other socio-economic problems
7. Change in climatic conditions
8. Scarcity of fuel wood and fodder
9. Flood hazards
10. Damage to hydel projects
11. Adverse impact on public health

Strategies to overcome the problems

1. **Implementation of law and regulations:** Besides, implementing family planning programme to relieve pressure caused by rapid population growth, Chinese Govt. successively issued some rules and regulations to control and prevent water loss, to protect and rationally use soil and water resources.

   i. Soil and water conservation provisional outlines of the People's Republic of China (1957)

   ii. Methods of soil and water conservation practices for small watershed (1980)

   iii. Soil and water conservation regulation (1982)

   iv. Soil and water conservation act of the People's Republic of China (1991)

Such types of stringent rules need to be imposed for a sustainable resource management approach.

2. **Combining erosion control with economic development:** Since eroded areas are usually poorer region, high farmer participation is not expected through controlling without economic profits. Only by combining control with local economic development, can the enthusiasm of farmers be motivated. Therefore, it is necessary to integrate with small projects viz. economic forestry, animal husbandry, fishery etc. This bring local farmers economic profits and thereby promote soil and water conservation directly or indirectly.

Approaches to soil and water conservation

A. Agronomic measures

Agronomic measure includes contour tillage, multistoried cropping, contour cultivation, cover cropping, mulching, grass cover, crop rotation, strip cropping, intercropping etc.

1. **Contour tillage:** It is also called as conservation tillage. It is understood as tillage practices specifically intended to reduce soil disturbance during seedbed preparation. This will improve soil structure and stability. It encompasses a range of tillage practices up to and including zero/no tillage.

2. **Multistoried cropping:** It makes efficient use of light, soil moisture etc. due to difference in height of component crop above ground and the spread of root system below ground. Crops requiring more sunlight form the upper canopy, while those requiring less light occupy the lower canopy. Because of this arrangement, competition for sunlight is reduced. Crops selected should also have different rooting behavior and root system.
3. **Contour cultivation:** Cultivation operations are done across the slope. This will increase the opportunity time and hence the infiltration of rainwater. It is more effective on moderate slop of 2-7% whereas both on flat or steep slopes the effectiveness is relatively less. On long slopes where bunding is done to reduce the length of slope, the bunds will serve as guide line for contour farming. All the cultivation has to be done parallel to these bund. Adoption of this method helps to retain soil and water in each contour.
4. **Cover cropping:** Growing cover crops in wastelands and cultivated field helps to cover the soil. Because of this, raindrops will be falling on the leaves of the cover crops and thus reduces the impact of it on the soil and protect from soil erosion. The cover crops also help to reduce the growth of weeds and minimize the loss of soil moisture due to evaporation. They will also add fertility to soil on decomposition. *Peuraria, Calapagonium, Centrosema, Mucuna* and *Mimosa* are some of the ideal cover crops that can be grown for this purpose. These crops on an average can give around 5 tonne of biomass from one hectare of land.
5. **Mulching:** It is a common practice in many areas to burn all the fallen leaves, crop residues and other waste material in the field. As this is not very ideal, it is recommended to use them as mulch between and around the plant basins; mulches will cover the soil and reduce the loss of soil moisture especially during dry periods. It will also help to reduce soil erosion during rainy period. It adds to soil fertility after decomposition. Thick mulching will also help to reduce the quick depletion of soil humus due to fast decomposition in tropical regions.
6. **Grass cropping:** Cultivation of suitable grasses or fodder crops in areas prone to soil erosion helps to minimize the loss of soil. This method is not only economical, but also help to produce sufficient fodder material when cattle rearing is also undertaken. Raising of fodder grasses on the contour bunds and soil bunds will enhance the life of such structures.
7. **Crop rotation:** Continuous cultivation of sloppy lands with crops that enhance soil erosion will lead to more erosion. Repeated cultivation of same crop in an area is not ideal due to many reasons. This will lead to depletion of

soil nutrients over the years and also lead to build up of pest and disease problems. Hence after the harvest of one crop another crop of different nature is to be raised in that field; e.g. cowpea, sesamum, groundnut, sweet potato or vegetables can be grown after the harvest of upland paddy in such areas.

8. **Strip cropping:** Soil and water conservation is possible by strip cropping in sloppy areas. Ribbon like strips with more length and less width can be made for cultivation along contour lines. This method of cultivation can be adopted across the slopes in areas where crops that cause soil erosion are to be raised. Upland paddy, cowpea, fodder grasses, vertiver etc. are ideal for strip cropping depending on the intensity of slope trenches and can be made at intervals of 3 to 7 m along the contours. These kinds of trenches and different crops raised on strips will help to reduce soil and water loss to a considerable extent.

B. Engineering Measures

It usually involves construction of mechanical barriers across the direction of flow of rainwater to retard or retain runoff and thereby reduce the soil and water losses. This measure includes contour bunding, graded bunding, bench terracing, trenching construction of grade stabilization structures, retention or detention reservoirs etc.

1. **Contour bunding:** Contour bunding is suitable for low rainfall area (<600mm) and for permeable soils to serve both as water and soil conservation measure, and is not recommended for soil with poor internal drainage. Its design involves determination of the spacing between the bunds, cross sectional area and the type of dimensions of the surplus system. Spacing is usually expressed in terms of vertical interval (VI). The basic principle involved in fixing the spacing is to keep the velocity of runoff below critical value which creates scour.

$$VI = 0.305 [(S/a) + b] \quad \ldots (1)$$

NB. Soil with good infiltration, a and b are 3 and 2 respectively. For soil of low infiltration, a and b are 4 and 2 respectively.

where,

VI is vertical interval in meter

S is percentage of slope

a and b are constants specific to a particular region

Taking climatic and vegetative cover into account M.P. Cox (USAID) formulated a formula

$$VI = 0.305 (SX + Y) \quad \ldots (2)$$

where

VI is vertical interval in meter

S is percentage of slope

X is rainfall factor and

Y is a factor due to soil infiltration and crop cover during erosive rain.

NB. Value of rainfall factor X

Rainfall, region	Annual rainfall, mm	Value
1. Scanty	<625	0.8
2. Moderate	625 - 875	0.6
3. Heavy	>875	0.4

Value of soil infiltration and vegetative cover factor Y

Soil type	Crop cover during rain	Value
1. Below average	low	1.0
2. Average or above avg.	good	2.0
3. One favorable & other unfavorable		1.5

Vertical spacing can be increased by 10% or by 15 cm to provide better location, alignment or to avoid any obstacle. Height of bund with 30 cm impounding is usual practice, 30 cm is provided as depth flow over outlet and 20 cm is provided as freeboard. This makes the overall height of 80 cm, with top width of 0.50 m and bottom width of 2.0 m and side slope of 1:1 the cross section works out to be 1 m^2.

Runoff volume from a 1 m wide strip will be

$$Q_v = (R_e/100) \times HI \quad \ldots (3)$$

Where,

Q_v is the runoff volume (cubic m)
R_e is 24 hour rainfall excess (cm) and
HI is horizontal interval in between bunds (m)

$$HI = (VI/ \text{slope in } \%) \times 100 \quad \ldots (4)$$

VI is vertical interval (m)

Area lost due to bunding

This helps in working out economics of bunding and to ascertain the net yield of crop after bunding. The actual area occupied by bunds depends on base width of bund slope and VI.

Length of contour bund per Hecter = 10,000/ HI = 100S/ VI ... (5)

Slope (S) = [VI/HI] x 100 ... (6)

Area lost (square meter) due to bunding per ha = (100S/VI) x b

b is base width of contour bund.

Percentage area lost due to bunding (excluding side and lateral bunds) =

(S x b)/ VI ... (7)

Assume length of side and lateral bunds to be 30% of length of main contour bund

Total length of bund per hectare = 1.3 x (10,000/ HI) ... (8)

Total area lost due to bunding per hectare = 1.3 x (100S/ VI) x b ... (9)

Note: Bunds can be used for growing grasses or crop like castor and thus compensate for area lost.

2. **Graded bund:** Graded bunds are constructed in relatively high rainfall (>600 mm) areas where the excess water is to be removed safely out of

the fields to avoid water stagnation. In case of highly impermeable soils like deep black soils graded bunds are recommended in areas with less than 500 mm of rainfall also. It is essentially meant for diverting excess water from cropped land to suitable outlets. The availability of water course with good vegetation is a pre-requisite.

3. **Bench terracing:** Bench terracing is practiced on steep hill slopes where agriculture has replaced natural forest and grass lands. It is also used on gentle slopes for uniform application of irrigation water. However, in rain fed areas, bench terracing is practiced normally in the 16-33% slope range. The bench terraces are of four different types:

a. **Level bench terraces:** Sometimes this type of terrace is referred to as table top or paddy terrace. Contrary to the usual concept that bench terraces are to be used on slope steeper than 6-7%, level bench terraces are required in paddy growing areas on slopes as mild as 1% to facilitate uniform impounding.

b. **Inwardly sloping bench terraces:** These are especially suited for steep slopes where it is essential to keep the excess runoff towards the hill (original ground) rather than on hill slopes. These terraces have a drain on inner side, which has a grade along its length to convey the excess water to one side, from where it is disposed of through a well stabilized vegetated water way. Used mainly in Nilgiri hills of Tamil Nadu as well as on steep Himalayan slopes in Himachal Pradesh and North Eastern hill region, all high rainfall area with deep permeable soils.

c. **Outwardly sloping bench terraces:** In place of low rainfall or shallow soils, the outwardly sloping bench terraces are used to reduce the existing steep slope to a mild slope (4-8%). In this type of soils not having good permeability, a graded channel has to be provided at lower end to safely dispose of surplus water to a water way in very permeable soils. A strong bund with spillway arrangement take care of most of the rainfall events while during heavy rainfall, the excess water may flow from one terrace to another.

d. **Puerto Rican or California type of terraces:** In this type of terraces, mechanical or vegetative barriers are kept on the original hill slopes at convenient distances and the terraces are formed gradually. With each plowing, the soil is pushed downward, thus gradually building up the terrace. The mechanical or vegetative barrier checks the soil so moved from being washed downward. For vegetative barrier, Guatemala grass or Napier grass can be used, planted along graded lines in two rows 30 cm apart and 22.5 cm stagger spacing terraces are progressively formed over a period of 2 to 4 years and cost 64 to 76% of conventional inward sloping bench terrace.

4. **Intermittent terraces (platforms):** Intermittent terraces are suitable on steep slopes (42%) where only

plantation crops are grown. The entire sloping land is not converted into step like terraces but only the crop rows are terraced following contours. In the sloping interspaces between two intermittent terraces usually cover crops are grown. Intermittent terraces are usually constructed with an inward slope so as to conserve the entire rainfall received.

5. **Moisture conservation pits:** Small pits can be constructed across the slope to harvest rainwater. Eroded soil will be deposited in the pits and water collected will be gradually infiltrated into the soil, thus increasing the moisture regime of agricultural land. They are suitable in between plantation crops, grown on flat and slightly sloping lands. Pits of size 1.5 m x 0.6 m x 0.6 m may be constructed at suitable intervals according to the site conditions.

6. **Crescent platforms/bunds:** Whenever plantation crops which don't require frequent intercultural operation and harvesting etc. are grown on steep slopes (>42%) inward sloping terraces can be taken around each tree usually in half moon shape. Such terraces are known as crescent platform. Cost of construction, soil disturbance etc. can be reduced significantly in this case.

7. **Contour trenches:** They are narrow trenches built along the contours for collecting and draining overland flow as well as for increasing soil moisture. They can be constructed continuously across the slope or in a staggered manner. Contour trenches are suitable on steep slopes where perennial crops are grown with less interspaces. They are also recommended in lateritic wasteland for intercepting overland flow.

8. **Check dams:** Check dams are embankments constructed across the flow of water. They can be either made of locally available material like brushwood, loose rocks, sand bags etc. or RCC structures. The major uses of check dams are:

   - To reduce the gully bed slope, thereby reducing the velocity of runoff water, preventing the eroding and down cutting of gully beds.
   - To encourage the deposition of silt and create favorable soil moisture regime for the establishment of plant cover.
   - To store water as a mini reservoir for irrigation or domestic use.

Where stones or rocks of appreciable size and suitable quality are available, they may be used to make check dams in gullies that have small to medium size drainage areas. Loose rocks boulder check dams reinforced with vegetative measures will form a very effective barrier against the flow of water. Such structures can be strengthened by encasing in woven wires called Gabiron structures. Brush wood check dams are low cost structures that can be constructed across streams in such

location where the velocity of runoff is not high. Poles of bamboo, arecanut palm, pine, casuarinas etc. may be drived in two rows across the drain and the space in between the poles is filled with waste material such as palm leaves, jungle woods etc. Poles drived are tied together with few poles placed across using GI wire so as to form a stable structure.

9. **Vegetative filter strips:** In places where runoff water is coming from upper hill area in considerable volumes, bunds of height 15 to 45 cm can be constructed across the slope and pine apple, vetiver and other grass strips can be established to filter the runoff and to prevent soil loss.

10. **Grassed waterways:** Grassed waterways serve as outlets for channel type terraces to conduct the surplus water safely to natural drainage course without causing gulling. Generally, the most ideal location for grassed water is a natural depression or drainage line where the slope is the flattest. Natural land slope confines the flow in these natural depressions and moisture conditions are usually most favorable for vegetative growth. Where grassed waterways can't be located in natural courses, they are artificially constructed and if possible along fence lines or hedgerow to avoid inconveniences to farm operations.

Usually these are constructed in three shapes viz. triangular, trapezoidal and parabolic. The parabolic shape is the most common as it is hydrologically more efficient and easy to construct. Even the other two shapes also ultimately tend to be parabolic in shape. The side slopes are kept very flat e.g. 8:1 to 10:1 to permit easy crossing by farm implements.

Design

The soil characteristics, land use vegetation patterns and topography classes in the area are determined which will help in working out the runoff coefficient (C). Then using rational formula, the peak rate of runoff (Q) for 10 years recurrence interval for the area is worked out

$$Q = CIA/360 \quad \ldots (10)$$

where,

Q is peak rate of runoff in cubic m/sec,

C is runoff coefficient,

I is intensity of rainfall, mm/h, and

A is catchment area, ha

After determining the peak rate of runoff the permissible velocity for the particular soil type and vegetation lining is decided. Generally the velocity range (V) varies between 0.9 to 2.1 m/sec.

After deciding permissible velocity, approximate cross sectional area of the channel can be worked out by

$$q = a \times v \quad \ldots (11)$$

where, $v = 1/n\ R^{2-3}\ S^{1/2}$ ... (12)

v is permissible velocity, m/sec,

n is Manning's Roughness coefficient (0.035 to 0.04)

R is hydraulic radius, m and

S is bed slop, percentage

A free board of 20% extra depth subject to a minimum of 15 cm depth is added to the computed value to take care of any higher flood of greater recurrence interval. Provision for extra depth to take care of the effect of retardance due to vegetation at its higher stage has to be made.

11. Ponds: Ponds are common structures used for rainwater harvesting. Two types of ponds are constructed viz. embankment type and excavated (dugout) type. Embankment type ponds are feasible in hilly and undulating topography where by constructing a small length of dam across a water course, maximum storage water can be affected. Depending on site conditions, storage/ earthwork ratios of 5 to 20 can be achieved. In flat area, embankment types of ponds are not feasible. In such areas, excavated ponds are constructed advantageously. In case of these ponds, the storage to earthwork ratio are relatively much smaller, generally around 1:0.

New ponds can be constructed on the sides of the drainage line. Side protection works such as rubble walls/stone pitching etc. can be done. The existing ponds can be renovated by de-silting and strengthening sides with vegetative or structural measures. In addition, stone quarries left in the field after cutting can be effectively used for collecting runoff water by constructing suitable diversion drains. Generally big ponds are constructed and subsequently lined with non- permeable sheets like *agrifilm, silpolin* or HDPE or with semi permeable coating of clay to reduce the seepage losses.

C. Biological measures

Apart from agronomic and engineering measures, biological measures on the other hand can provide permanent soil erosion control and reduce water nutrient loss. Plant measures concentrate on planting fast growing trees, bushes and herbs. Trees, bushes and herbs are grown together in a certain proportion when revegetating. The combination of plants contributes beneficially to revegetation and can help to form a multilayer canopy. Such vegetative canopies provide beneficial erosion control and soil fertility enhancement.

Conclusion

Sustainability of the land resource base has become a great concern in recent years. Regenerative agricultural technologies for the sustainable development of hilly areas in respect of soil and water management must integrate socio-economic issues and bio-physical processes.

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SCIENCE OF THE MONTH

N.S. Arun Kumar

MARCH 2011

March 1: The Government will establish The India-based Neutrino Observatory (INO) jointly by the Department of Atomic Energy and Department of Science and Technology. A site in Bodi West Hills near T. Pudukottai village of Theni district, Tamil Nadu has been identified as a suitable location. The project includes construction of a world-class underground laboratory under a rock cover of 1200 metre from all directions. The primary goal of INO is to study neutrino properties. Link: http://www.imsc.res.in/~ino

March 2: Earth is worth £3,000 trillion, according to an astrophysicist who claims to have created a formula to calculate the value of a planet. The astrophysicist, Greg Laughlin from University of California, came up with the figure by calculating the sum of the planet's age, size, temperature, mass and other vital statistics. Laughlin invented the equation, which he used to evaluate the discoveries made by US space agency NASA's £600 million Kepler spacecraft. Link: http://www.ucolick.org/~laugh

March 3: Robonaut 2 has become the first humanoid robot ever to reach space. It was transported to the International Space Station via. the Space Shuttle Discovery. The Robobaut is a dextrous robot designed by General Motors and NASA engineers and is on its first mission. Robonaut, or R2, does not have a specific job aboard the station and will perform maintenance and service tasks. The robot has 38 computer processors. Link: http://robonaut.jsc.nasa.gov/default.asp

March 4: India has applied to the European Organisation for Nuclear Research (CERN) at Geneva in Switzerland for associate membership. This was stated by CERN official Rudiger Voss who said if India is granted associate membership, Indian researchers would be eligible for jobs at the CERN. At present, CERN has 20 member-States. Currently, researchers of institutes that collaborate with the CERN can only be deputed there for short periods of time. Link: http://public.web.cern.ch/public

March 5: Paleontologists believe that at least seven species of Dinosaurs lived in the tiny town called Balasinor of Raiyoli Taluk in Gujarat making Raiyoli the third largest hatchery in the world. In 2003 they also discovered a new species here named *Rajasaurus narmadensis*, meaning "the princely reptile from the Narmada". The site was discovered accidentally in 1981 when geologists were conducting a mineral survey of the area. Link: http://www.dinohunters.com/History/Rajasaurus.html

March 6: The number of spots on the Sun's surface varies periodically, going through successive maxima and minima in roughly 11 year solar cycles. Now a team of scientists led by Assistant Professor Dibyendu Nandy from the Indian Institute

of Science Education and Research in Kolkata, has developed a model which may explain why some solar cycles are worse than others. The study is reported in the journal *Nature*. Link: http://www.nature.com/nature/journal/v471/n7336/full/nature09786.html

March 7: The Great Indian Bustard has recently been declared as Critically Endangered by the Bird Life International, a global alliance of conservation organisations, and the International Union for Conservation of Nature (IUCN). Environmentalists and experts say that this upgradation of category of the Great Indian Bustard will give priority to its conservation and protection. At present, the bustard population in six states, including Maharashtra, is just 300.Link: http://www.birdlife.org/, http://www.iucn.org

March 8: Discovery ended its career as the world's most flown spaceship on Wednesday, returning from orbit for the last time and taking off in a new direction as a museum piece in Smithsonian Institution. Even after shuttles Endeavour and Atlantis make their final voyages in the coming months, Discovery will still hold the all-time record with 39 missions, 148 million miles, 5,830 orbits of Earth, and 365 days spent in space. . Link: http://science.ksc.nasa.gov/shuttle/resources/orbiters/discovery.html, http://www.si.edu

March 9: Eminent astrophysicist Jayant Narlikar will be the recipient of the prestigious 'Maharashtra Bhushan' award for 2010. The award - instituted in 1997 by the Maharashtra government to recognise the highly distinguished achievements of eminent persons from the state, representing different walks of life - carries cash Rs 5 lakh, a shawl and shriphal (traditional coconut) and a citation. He has received several awards including Padma Bhushan in 1965, at the young age of 26. Link: http://maharashtra.gov.in

March 10: Richard Hoover, a NASA scientist reports detecting tiny fossilised bacteria on three meteorites, and maintains these microscopic life forms are not native to Earth. If confirmed, this research would suggest life in the universe is widespread and life on Earth may have come from elsewhere in the solar system. The study is published in the *Journal of Cosmology*, is considered so controversial as the journal's editor seeks other scientific comment on this. Link: http://journalofcosmology.com

March 11: James Elliot, an astronomer who used light from distant stars to study planetary objects throughout the solar system, leading to his discovery of the rings of Uranus, died on March 3 at his home in Wellesley, Mass. He was 67. In 1977, using a telescope in an airplane, Dr. Elliot led a team of Cornell University scientists to observe the planet Uranus when it passed between Earth and a star, recording the first evidence of Uranus's rings. Link: http://web.mit.edu/physics/people/faculty/elliot_james.html

March 12: India successfully test-fired its homegrown nuclear-tipped ballistic missiles Prithvi-II and its naval version Dhanush from different locations off the Orissa coast, on a day Pakistan too tested its nuclear-capable Hatf-II ballistic missile. The Prithvi-II was fired from complex-3 of the Integrated Test Range

(ITR) at Chandipur in Balasore district. Pakistan too successfully test-fired the Hatf-II (Abdali) short-range surface-to-surface ballistic missile. Link: http://www.mod.nic.in

March 13: The devastating tsunami that struck Japan on March 11 was "completely unrelated" to the approaching "supermoon," according to U.S. Geological Survey. The supermoon will occur on March 19, when the moon is at or near its point of closest orbit and is also full. However, a very small correlation exists between full or new moons and seismic activity, because the stronger-than-usual tidal forces caused by the alignment of the sun and moon puts added stress on tectonic plates. Link: http://www.usgs.gov

March 14: The massive earthquake that struck northeast Japan on March 11 has shortened the length Earth's day by a fraction and shifted how the planet's mass is distributed. A new analysis of the 8.9-magnitude earthquake in Japan has found that the intense temblor has accelerated Earth's spin, shortening the length of the 24-hour day by 1.8 microseconds, according to geophysicist Richard Gross at NASA's Jet Propulsion Laboratory in Pasadena. Link: http://www.jpl.nasa.gov

March 15: The Royal British Mint has released a 50 pence coin to mark the 50th anniversary of the founding of the World Wildlife Fund. Centered around the charity's iconic panda logo at the heart of the design, is a dolphin, gorilla, rhino, polar bear and butterfly. Other symbols featured on the coin include a car, a wind turbine, coffee bean, and a human footprint to represent man's impact in the world. The reverse design was created by award winning graphic artist Matthew Dent. Link: http://www.royalmint.com

March 16: A whale shark was satellite-tagged for the first time in India, as part of research to understand behavior, ecological preferences and migration of this species. The satellite tag was installed by a team of researchers under the Whale Shark Conservation Project. Since its inception in 2008, the Whale Shark Conservation Project has been working with the support of the fishing communities, involving them in the conservation of this largest fish in the world. Link: http://www.whalesharkproject.org

March 17: Scientists at the Norwich Research Park in the United Kingdom have successfully sequenced the genome of a novel strain of *Clostridium botulinum* that can produce a deadly neurotoxin and could be used as biological terrorism weapon. The strain produces an unusual botulinum neurotoxin called type A5 neurotoxin, News-Medical.net reports. By sequencing the complete genome, the researchers hope to be able to manage any possible threat that the new strain poses. Link: http://www.nrp.org.uk

March 18: Researchers are trying to sequence the complete genome of the world's largest fish, the Whale Shark. Researchers at Emory University and the Georgia Aquarium are working to create a complete library of Whale Shark DNA, sequencing the genomes of the aquarium's captive sharks, which come from Taiwan, and comparing them with wild whale sharks in Mexico. The genome sequencing project will take months to complete. Link: http://www.georgiaaquarium.org/,

http://www.emory.edu/home/index.html

March 19: The Large Hadron Collider (LHC), the world's largest atom smasher that started regular operations last year, could be the first machine capable of causing matter to travel backwards in time. If the collider succeeds in producing the Higgs boson, some scientists predict that it will create a second particle, called the Higgs singlet. According to Weiler and Chui Man Ho's theory, these singlets can move either forward or backward in time and reappear in the future or in the past. Link: http://public.web.cern.ch

March 20: For more conservation measures and research on common bird species and urban biodiversity, March 20 will be celebrated and marked as World House Sparrow Day. The marking of the day is an international initiative by the Nature Forever Society, in collaboration with the Bombay Natural History Society, Cornell Lab of Ornithology (U.S.), Eco-Sys Action Foundation (France), Avon Wildlife Trust (U.K.) and numerous other organisations. Link: http://www.natureforever.org

March 21: For the first time, Earth has a regular orbiting eye-in-the-sky spying on the solar system's smallest and strangest planet, Mercury. NASA's spacecraft called Messenger successfully veered into a pinpoint orbit after a 6 1/2-year trip and 4.9 billion miles (7.9 billion kilometers) and tricky maneuvering to fend off the gravitational pull of the sun. It is the fifth planet in our solar system that NASA has orbited, in addition to the Earth and the moon. Link: http://www.nasa.gov/mission_pages/messenger/main

March 22: A new species of a Rugged Darkling Beetle that thrives in an arid region of the Chihuahuan Desert is being named in honor of Theodore Roosevelt on the 100th anniversary of a speech he gave at Tempe Normal School, now Arizona State University. The new species of beetle, *Stenomorpha roosevelti* was discovered and named by Aaron Smith, an authority on darkling beetles and a postdoctoral research associate at Arizona State University. Link: http://species.asu.edu

March 23: Scientists at Brown University in Providence, Rhode Island, have discovered a new type of moon rock thanks to the Moon Mineralogy Mapper instrument aboard the Indian Space Agency's Chandrayaan-1 spacecraft. The imaging spectrometer took the first high resolution pictures of the far side of the moon. Evidence of the new type of moon rock, believed to be a form of pink spinel, was found on the edge of the Moscoviense basin on the far side of the moon. Link: http://m3.jpl.nasa.gov

March 25: The fossilised remains of the world's largest known rabbit, *Nuralagus rex* have been found off the coast of Spain. The animal, which lived three to five million years ago and was six times the size of most rabbits today, has been dubbed the "Minorcan King of the Rabbits", since it was found on the small Mediterranean island of Minorca. Researchers at the Catalan Institute of Paleontology report their discovery of the new species in the *Journal of Vertebrate Paleontology*. Link: http://www.vertpaleo.org

March 26: Japanese scientists have found measurable concentrations of iodine-131

and caesium-137 radiation in seawater near the crippled Fukushima nuclear plant. The iodine concentrations were at or above Japanese regulatory limits, and the caesium levels were well below those limits, says International Atomic Energy Agency (IAEA).Food products from the affected areas near the plant were found to have levels of iodine-131 and caesium-137 had exceeding acceptable limits. Link: http://www.iaea.org

March 27: A new species of seabird has been recognized in Puerto Montt, Chilea. It is a new species of Storm Petrel, the first new species of seabird in 55 years. The announcement was made at a recent ceremony held by the San Diego Bird Festival. Thousands of Storm Petrels are found along the Chilean coast but scientists missed this new species. Storm petrels, 22 species in all, are called "the ballerinas of the sea" as they seem to dance on water with their webbed-feet. Link: http://www.sandiegoaudubon.org

March 28: NASA says the unmanned spacecraft Stardust will burn off all its remaining fuel in a single burst today, and then its transmitter will be shut off and the spacecraft left to drift. Stardust will transmit information about its fuel usage as the burn happens. Since it was first launched in February 1999, Stardust has traveled more than 5.5 billion kilometers. It has flown past an asteroid and two comets, and has returned comet particles to Earth in a sample capsule. Link: http://www.stardust.jpl.nasa.gov

March 29: India's latest tiger census shows an increase in the numbers of it. The census counted at least 1,706 tigers in forests across the country, about 300 more than four years ago. The census included 70 tigers in the eastern Indian Sunderbans Tiger Reserve, which had not been counted in the last census in 2007. The 2007 census had shown 1,411 tigers, a sharp fall in the population from about 3,600 five years earlier.A century ago, about 100,000 tigers roamed India's forests. Link: http://projecttiger.nic.in

March 30: Scientists have created the world's first artificial leaf that can turn sunlight and water into energy. A team at Massachusetts Institute of Technology says that the artificial leaf from Silicon, electronics and various catalysts which spur chemical reactions within the device, can use sunlight to break water into Hydrogen and Oxygen which can then be used to create electricity in a separate fuel cell. The findings were presented at the National Meeting of the American Chemical Society. Link: http://web.mit.edu

March 31: Shri Jairam Ramesh, Minister of State for Environment and Forests today launched Black Carbon Research Initiative National Carbonaceous Aerosols Programme (NCAP). It is a joint initiative and Ministry of Environment and Forest, Ministry of Earth Sciences, Indian Space Research Space Organisation and Department of Science and Technology are working together. The National Institute of Glaciology has been set up in Dehradun already related to this. Link: http://envfor.nic.in

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Patent Strategy and Management for R & D Organizations

D. Bheemeswar

Introduction

R & D platform has invented a technology that creates a new product and process for the way of doing business. Early in the development of the new platform, a detailed patent application is prepared, filed and prosecuted and obtained. Before granting, a well-funded competitor begins using the patented technology. When the patent issues, a cease and desist letter is sent. The competitor denies infringement and a lawsuit is filed. At trial the claims of the patent are interpreted, found to be infringed, and judgment is granted in favor. The defendant, the competitor, appeals; the court interprets the claims more narrowly, finds non-infringement and reverses earlier judgment. In such cases the best strategy is to file early and file often in continuation of earlier filings of the patents, a business approach to IP.

A business approach for a successful R & D IP include a) Invention Management of IP, b) Competitive Intelligence of IP, c) Information Technology for IP, d) Continuation of Patent Application, e) The Risk of Narrow Claim Interpretation, and f) File Early and Often.

Strategy

A business approach for a successful R & D IP include a) Invention Management of IP, b) Competitive Intelligence of IP, c) Information Technology for IP, d) Continuation of Patent Application, e) The Risk of Narrow Claim Interpretation, and f) File Early and Often.

Invention Management of IP

a) Focusing on innovation/ generation categorization and optimization of ideas and concepts,

b) Find out how to get more invention disclosures of patent application for that particular field, at least 10-15 times more,

c) Learn ways and means to improve the quality of the patent applications by comparison with the closest prior art, at least by 70-80%,

d) Totally eliminate inventor's bias or

partiality, this shall improve the patentability up to 90-95%, and

e) Give better incentive for each invention that has been filed or granted.

Competitive intelligence of IP

a) By providing information on competitors in the filed to improve the quality of decisions around R & D organization. This is generally done on reviews or paper presentation and also from internet,

b) By optimizing invention the infringement litigations can be reduced over the prior art, in turn improves the quality of the patent application, and

c) By offensive method challenge the competitors and defensive methods go on filing the patent applications one after other more often.

Information Technology for IP

a) A well custom developed information technology for those who are dealing with IP, like drafting and helping during the defense,

b) Let the IP personal deal with IP rather not on Information technology, this enables them to concentrate on basics of patenting filing structures, like claim drafting based on the close prior art and also to other fields of application that the invention may go,

c) As far as possible get all answers before you forget what was requested, before starting to write patent application, and

d) Better utilization of the up to date data to increase the quality of the patent application.

Continuation of Patent Application

a) Given the current trends in claim interpretation climate, the best approach for a IP personal, may be, filling one or more continuation application to avoid possible infringement and also to capture competitors products, even during the litigation if necessary.

b) This can avoid or rectify a narrowing claim interpretation. In addition, the filing of continuous applications also can help capture business in better ways.

c) Competitor may have to modify his/her product or process or both in order to avoid the possible infringements.

d) There is nothing wrong or improper or illegal or inequitable in filing patent application for the purpose of obtaining a right to exclude a known competitors product or process or both from the market.

e) It is permissible to analyze R & D competitor's product or process or both and then amend the claims of the patent application that is pending or add new claims to better capture the competitors product or process or both. Of course an applicant cannot amend the claims unless the original application supports the proposed amendment.

f) Assuming it does redrafting or filling a new application to capture the competitors product or process or both can help an applicant withstand a narrow interpretation or an attempted design around.

The Risk of Narrow Claim Interpretation

a) By maintaining a pending application, the R & D organization can, if necessary amend the claims of the continuation application to address the alleged deficiencies noted by the competitor,

b) The same scenario applies with respect to those attempting to design around an issued patent, and

c) The cost of pending application is not that high as that of infringement suit and subsequent appeals, A typical infringement suit in US costs about $750,000 to $3,750,000 depending on how much money is at stake, at an average cost of $2,125,000 per case for a case having $1million to $25 million at risk, spending another $10,000 to $20,000 for continuous application is nothing but reasonable but also gives an edge over the competitor.

File Early and Often

a) The best approach to have an edge over the competitors is that file a patent application early,

b) Continue the work and file the patent application quite often,

c) Review the competitor's products and processes and go on modifying ones product and file the results in order to keep the competitor at bay and enjoy a comfortable market for your product or process or both, and

d) This helps to have a chance in the event of narrow down claims to better or redraft the claims in the pending application.

Conclusions

It is concluded that in the ever changing interpretations of the claims infringement in a patent application it is better to have more than one patent in continuation to capture the competitors product or process or both for an R & D organization as to get better business and also to have more credibility. Encourage the innovators who are working and filing the patent applications in the same field for getting more and more industry oriented research from the science to better technology out puts.

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Ayurvedic methodology of learning – A brief review

Dr. Asit Kumar Panja

Abstract

Vedic methods of study represent the earliest form of education and intended to achieve retentive memory (Sruti). The four slopes of education namely the student, the teacher, method of study and application were pondered equally important. In classical period *Svadhyaya* (*Adhyayan*) and *Pravachana* (*Adhyapana*) were the main methods for learning which starts after *Upanayana*. These educational system is totally incorporated with proper study method (*Patha*), proper teaching methods (*Avabadha*) and practical study (*Anusthana)*.

Introduction

Instinct is the inner compulsion which animal organisms feel in the choice of what is good and beneficial for its survival and protection. As a rational animal, humans always try to get maximum benefit by loosing minimum energy. The ancient methods of learning also emphasize this. The Vedic strategy of study i.e. *Svadhyaya* and *Pravachana* (Yoga Sutra - Introduction) incorporates the Ayurvedic *Adhyayana*, *Adhyapana* and *Tadvidya Sambhasha* (Charaka Viman 8/6). Apart from the methods of study the student, teacher and applicator were also given equal importance. Being a practical science, Ayurveda emphasizes on selection of medical text and examination of teacher (Charaka Viman 8/8), student etc. (Charaka Viman 8/4). It is most surprising that in that period also apart from *Varna-bhada* students were assessed by their moral and intellectual qualities (Sushruta Sutra 2/3) then they had to undergo through probation period in which they were further assessed finally living scope for improving weak areas. By this way unworthy person are excluded from entry in the field.

The importance of all round or comprehensive knowledge and even danger of partial knowledge were vividly elicited (Charaka Viman 7/4). So, avoiding narrow specialization, the students are advised to pay special attention to have full and clear understanding of the technical terms (Charaka Viman 8/5), to be acquainted with a number of other related sciences and to learn those sciences from the expert in that particular branch (Sushruta Sutra 4/6).

According to the classical practice, student should learn to recite *Pada* by *Pada* (word by word), quarter verse (*Pada*) to whole verse (*Sloka*) (Sushruta Sutra 4/5). Then these words, quarter verses and whole verse should be connected in the order again and again like quarter verse with word and whole verse with words and quarter verses. Having formulated them the verse should be repeatedly recited. Here *Pada, Pada* and *Sloka* (i.e. word, quarter verse and whole verse respectively) are designed for the three degrees of intelligence of the pupils and should be taught according to ability. Lastly after the pupil finished his reading the teacher himself should recite so that the student might follow him for easy reading (Sushruta Sutra 4/8). Not only that the ancient system of medicine also stress to achieve the oral fluency (Sushruta Sutra 3/36). The ancient sages have given special attention for cultivating the power of memory for that they postulated and formulated a most concise style or sutra form of comprehensive encyclopedic books to minimize the burden of brain.

According to the classical practice student should learn to recite *Pada* by *Pada* (word by word), quarter verse (*Pada*) to whole verse (*Sloka*) (Sushruta Sutra 4/5). Then these words, quarter verses and whole verse should be connected in the order again and again like quarter verse with word and whole verse with words and quarter verses.

In the next step teacher explains the entire text on the basis of *Pada, Pada* and *Sloka* with proper meaning for the easy grasping of the student (Dalhana on Sushruta Sutra 3/6).

The third step of (study) *Adhyayana* is through study with interpretation regarding purposeful borrowed ideas (Charaka Viman 8/7).

The final step of *Adhyayana* is the practical consequential training. In this period, student having studied the entire scripture should be subjected to practical work (Sushruta Sutra 9).

Hence, through the entire processes of *Adhyayana* efforts have been made to attain excellence of speech, understanding, boldness, dexterity, practice and successful management (Charaka Viman 8/7).

Excellence of speech is also attained by practice of lecturing and participation in symposia and seminars (Charaka Viman 8/15), the ideas are understood by repeated study of treatise and boldness comes by self confidence produced by knowledge (Charaka Viman 8/15).

The second important step of acquiring knowledge is *Adhyapana* (teaching) (Charaka Viman 8/8). It makes the subject clear to the person himself and enable him to acquire an aptitude for imparting it to others. *Harita Samhita* described three dimension of *Adhyapana* i.e. for achieving Dharma, earning money and serving. In the initial stage of teaching one should enter into the topics after subsequently following the text (*Samhita*), *Sathan* and *Adhyayas*.

In the second step topic should be described in the light of *Vakyasa*, the entire text as it is (Charaka Sutra 30/17), *Vakyarthasa*, comprehensible explanation of text through expanding, brevity, proposition, reasoning, examples, correction and conclusion as per the grades of pupils (Charaka Sutra 30/18) and *Arthvayvasa* i.e. discussion and recapitulation of the difficult point in the text by repeated practice (Charaka Sutra 30/19). Following this method a teacher should explain the text theoretically. After that the teacher should give time required for practical training (Sushruta Sutra 3/56) and make the student confident in their subsequent field.

The instant method of teaching as emphasized by Lord Atreya are as follows:

1. Announcement of the definite subject as per need.
2. Inquisitive enquiry from the student in order to spot light the salient features of proposed subject.
3. Covering up the whole field of proposed subject while expounding the salient feature on the basis of arising question.
4. Intelligent interjection for giving further classification on points
5. Ultimately summing-up the entire subject briefly.

The third and final step of study is *Tadvidya sambhasa*. Though it is incorporated within Adhyayana and *Adhyapana vidhi,* after looking at the distinctive nature it is also emphasised separately (Charaka Viman 8/15). It helps to promote the pursuit and advancement of knowledge, provide dexterity, improve power of speaking, illumine fame, remove doubt in text by repeating the frames, creates confidence in case there in no doubt and brings forth some new ideas of unknown (Charaka Viman 8/15).

Conclusion

It may be concluded from the above discussion that the edifice of the education system must include three fold system of *Vagbhata* i.e. *Patha* (proper study method), Avabodha (proper teaching methods) and *Anusthana* (proper practical study). Teaching must be simplified. Multidisciplinary approach is necessary to establish the principles.

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SCIENCE INDIA QUIZ

Send the correct answers to Science India office or to arsmenon@gmail.com/scienceindia2010@gmail.com latest by 20th May, 2011. A science book as prize awaits you. If there are more than one correct entries, the winner will be selected by draw of lots

- ***Editor***

SCIENCE INDIA QUIZ NO. 18

1. The minimum height of a plane mirror required to see one's own image from head to foot is -------
2. Bauxite is an ore of -------
3. A tissue which gives mechanical support to plant part is -------
4. Total volume of blood in a normal adult human being
5. The chemical name of table salt
6. Myopia is a disease connected with -------
7. Rate of change of velocity of a body
8. Science of throwing missiles and studying its flight path
9. Fear of ugliness
10. All the operands and results of computer operation directed by the detailed instructions comprising the programme

Answers to Quiz No. 17

1. Elasticity 2. 24 3. Organic acids 4. Vitamin K 5. Silver 6. Brain 7. Ablutophobia 8. Balard 9. Cacography 10. Dalton

The winner is Kum. Rehna Muhammed, Govt. High School, Malappuram
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